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CHARACTERISTICS OF THE STRUCTURE OF ICHTHYOFAUNA ASSEMBLAGES IN THE LITTORAL OF THE LOBELIA-LAKE LAKE DOŁGIE WIELKIE AND THE ANALYSIS OF FISHERIES CATCHES

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ABSTRACT. The aim of the work was to characterize the species composition of the fish assemblages in the littoral zone and to analyze catch statistics from the lobelia-lake Lake Dołgie Wielkie. Catches were conducted with a fry trawl between May and August 2001 in the shallow littoral. Commercial catches from 1952 to 1970 and 1980 to 1999 were also analyzed. Nine fish species were caught and the majority (81.1%) of specimens belonged to the juvenile stages. The greatest contribution (%) to the littoral fish assemblage was made by belica, which was also described by the highest availability coefficient. A small number of species which comprised the lake fish assemblage and the distribution of their frequency of occurrence meant that the Simpson coefficient (D) of species diversity was low at 0.2082. The littoral of Lake Dołgie Wielkie is not very diverse and the ichthyofauna diversity in it is dominated by belica. In comparison with lobelia-lakes in western Pomerania, the structure of the share of various species in commercial catches was different in Lake Dołgie Wielkie, and the fisheries yield was higher. The fish assemblage which inhabits the lake is characteristic of eutrophic lakes.

Key words: LOBELIA LAKE, ICHTHYOFAUNA, COMMERCIAL CATCHES, SŁOWIŃSKI NATIONAL PARK

INTRODUCTION

Lobelia-lakes, with their characteristic glacial flora represented by water lobelia *Lobelia dortmanna* L., *Isoëtes lacustris* L., and *Litorella uniflora* (L.), are unique aquatic basins which are rare in Poland. They are located in woods and acidophilus forests and often either have no outlet or are located in the upper river basins of small tributaries. Their ecosystems are stable with a low trophic level (Kraska et al. 1996). The presence of macrophytes increases habitat structures and provides opportunities for diverse fish assemblages to gather (Bryan and Scarnecchia 1992). They also provide juvenile fish with good hiding places from predators (Savino and Stein 1989).

Most of the Polish coastal lakes are located in western Pomerania, the Charzykowska Plain and the Kaszubian Lake District; of these only Lake Dołgie Wielkie is classified as lobelian (Kraska et al. 1996). In contrast to other coastal lakes

which are typical brackish water basins thanks to the periodic inflow of marine waters, the concentration of Cl ions in this lake is equal to that in fresh inland water bodies. On average, the concentration is 25 mg Cl^{-} dm^{-3}, i.e., 0.0011‰, which means that Lake Dołgie Wielkie can be classified as limnetic (Trojanowski, unpublished data). This lake, which is a closed nature reserve, might have maintained its natural, unchanged state and thus be valuable in comparative studies. To date, only studies of the flora (Piotrowska 1997) and the ecology of leeches (Hajduk et al. 1978) have been conducted at this site. No publications exist regarding the ichthyofauna of this lake. Low fisheries productivity, which stems from the low plankton and zoobenthos biomass, has meant that this lake is of little interest to fishermen or ichthyologists. The body of knowledge regarding the ichthyofauna of lobelia-lakes is small and in the majority of cases regards only commercial species (Heese 2000). Works regarding the ichthyofauna of coastal lakes are very few and are focused mainly on the analysis of fisheries catches (Orzechowski 1997, Heese 1998, Ciepielewski 1999) or issues concerning growth and fish migrations (Nagięć 1961, Zawisza 1970). The aim of the present study was to describe the species composition of the littoral fish assemblage and to analyze catch statistics from Lake Dołgie Wielkie.

STUDY AREA

Lake Dołgie Wielkie is directly adjacent to the Baltic Sea and is located between the Gardno and Łebsko lakes in the Słowiński National Park (Fig. 1). It was created

Fig. 1. Area of studies. Location of Lake Dołgie Wielkie.

when a bay was separated from the deep main part of Gardno lake by shifting sand dunes. The basin of Lake Dołgie Wielkie stretches longitudinally from the west to the east, and it is separated from the sea by a length of sand dunes which are overgrown with a seaside crowberry forest typical of dune areas and acidic or poor soils (Piotrowska 1997). The shallow depth of the lake means that conditions are good for catching fish with hauled gear (Table 1). The lake is supplied by precipitation and

TABLE 1

Limnological and hydrological parameters of Lake Dołgie Wielkie and its drainage area (data from IFI, Olsztyn)

Parameter	Value
Area of lake (ha)	156
Depth (m)	
maximum	2.9
average	1.6
Volume (m^3)	215.18×10^4
Size (m)	
maximum length	2650.1
maximum width	930
Shoreline (m)	6675

periodic inflows of water in its eastern part. It has a permanent outflow which connects it with the Gardno-Łebsko canal.

The vegetation which occurs here is typical of lobelia-lakes and includes *Lobelia dortmanna* L., *Isoëtes lacustris* L., *Litorella uniflora* (L.), and *Myriophyllum alterniflorum* DC; this last plant is characteristic of the most eutrophic lakes of this type (Kraska 1997).

MATERIALS AND METHODS

The study materials were caught with a fry trawl (mesh bar length - 1 mm, wing length - 2.5 m, height - 0.6 m) from May to August 2001. The catches were made in the shore zone at fixed stations according to a set procedure, so that the area of each haul was the same and the range of the trawl extended from the surface to the bottom. The stations were selected to include the most diverse littoral assemblages located throughout the lake. The fish caught were preserved in a 4% formaldehyde solution and then determined to the species level according to morphologic and anatomic characters

(Horoszewicz 1960, Koblickaya 1966, Mooij 1989). Water temperature, Secchi disk visibility and the periodic dissolved oxygen contents were measured during the catches.

The Simpson - species diversity coefficient (*D*) was used to determine the species abundance (Krebs 1998):

$$D \quad 1 \quad \sum_{i\ 1}^{S} (p_i^2)$$

p_i = percentage of specimens of species and in the assemblage.

This coefficient varies from 0 (minimum – small diversity) to $1 - 1\ S^{-1}$, where S is the number of species.

The frequency of occurrence of all fish species in the littoral was described by the fish availability coefficient, which is the ratio of the number of samples in which a species occurred and the number of the samples collected (Mikulski and Tarwid 1951). In general, this coefficient describes the frequency of the occurrence of particular species; the values of this are described by a four-degree scale: 0.0 – 20% - low availability; 20 – 60% - average availability; 60 – 90% - high availability; 90 – 100% - exceptionally high availability.

The dominant fish species in the lake littoral were determined based on the numbers of fish. The contribution ranges (%) in the fish assemblages were taken from Terlecki (1993) and the category names from Engelmann (1978).

Commercial fishing log books were used to analyze the catches made in Lake Dołgie Wielkie from 1952 to 1999, during which fish were caught at varying intensity, but primarily with hauled gear.

The results were analyzed with the t-test and the U Mann-Whitney test and the software Statistica version 6. The hypothesis that there were insignificant differences between the average fisheries yield (kg ha^{-1} $year^{-1}$) in years when there were intensive catches and in those when the catches were sporadic was verified with the t-test. Test U was used to compare the abundance of species whose share of the shallow littoral fish assemblage exceeded 0.5%.

RESULTS

During the study period, the water temperature varied from 6.5 to 26.2°C, dissolved oxygen content ranged from 10.0 to 13.6 mg O_2 dm^{-3}, and Secchi disk visibility – from 0.2 to 0.9 m (Fig. 2).

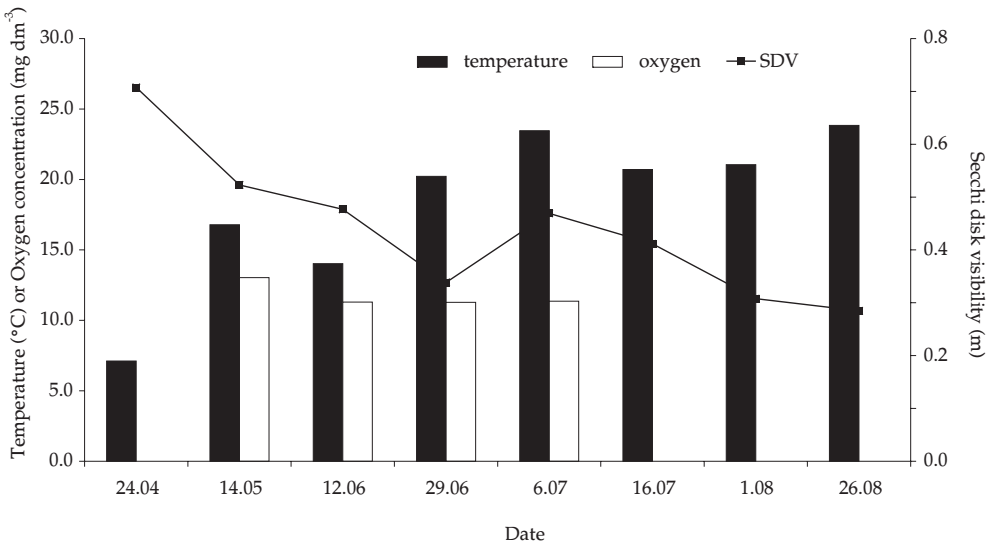

Fig. 2. Average water temperature, dissolved oxygen contents and Secchi disk visibility - SDV in 2001.

A total of 4571 fish representing nine species were caught (Table 2). The highest fish numbers were noted at the beginning and end of sampling, at seven and eight species, respectively. The average number of fish in one haul was 109 specimens, the majority of which (81.1%) were from the 0+ age group, further referred to as fry. Belica *Leucaspius delineatus* (Heck.) was the eudominant in the littoral and occurred in all sampling periods. Its contribution to the fry assemblages was the same as among older fish. Roach *Rutilus rutilus* (L.) was the subdominant and perch *Perca fluviatilis* L.

TABLE 2

Characteristics of fish catches with a fry trawl in the littoral of Lake Dołgie Wielkie in 2001

Date	Number of hauls	Number of fish	Average number (individual × haul $^{-1}$)	Number of species	Share of fry in fish assemblages (%)
14 May	7	480	69	7	0
12 June	5	940	188	6	83.94
29 June	8	2552	365	6	94.55
6 July	8	145	24	5	90.34
1 August	7	283	47	6	83.74
21 August	7	171	29	8	88.89

TABLE 3

Share (%) of species in catches and the availability of fish in the littoral of Lake Dołgie Wielkie

	Species share (%)			Availability		
	total	age group > 0+	age group 0+	total	age group > 0+	age group 0+
Belica	88.62	87.02	88.99	95.2	71.4	61.9
Roach	7.77	1.04	9.34	33.3	19.0	16.7
Perch	1.82	3.82	1.35	69.0	21.4	52.4
Rudd	0.63	3.13	0.05	31.0	28.6	4.8
Gudgeon	0.55	2.32	0.13	23.8	19.0	7.1
Ruffe	0.55	2.43	0.11	19.0	16.7	7.1
Common bream	0.02	0	0.03	2.4	0	2.4
Spiny loach	0.02	0.12	0	2.4	2.4	0
Pike	0.02	0.12	0	2.4	2.4	0

was recedent, which, although not numerous, occurred in all the sampling periods. The other species occurred very sporadically (< 1%), and the following species always occurred in subsequent catch periods: rudd *Scardinius erythrophthalmus* (L.); gudgeon *Gobio gobio* (L.); ruffe *Gymnocephalus cernuus* (L.); pike *Esox lucius* L.; spiny loach *Cobitis teania* L.; common bream fry *Abramis brama* (L.). Significant differences in the numbers of the various species in the littoral of the lake were observed between belica and the other species and between perch - rudd and gudgeon - ruffe ($P < 0.05$, test U). The Simpson (D) species diversity coefficient was 0.2082. Belica belonged to the group of species which had exceptionally high availability, perch - high availability, roach, rudd and gudgeon - average availability. The remaining species had low availability (Table 3).

Commercial fish catches were conducted in this lake from 1952 to 1970 and from 1980 to 1999. In the first time period, they were conducted annually, except in 1962 and 1964 when fish were not caught in the lake. During the second time period, fish were caught sporadically, i.e., only in 1980, 1981, 1984, 1987 and 1999. Stocking was performed irregularly – three times with pike fry (from 1952 to 1954) and pikeperch *Sander lucioperca* (L.) (in 1952-1960), and six times with carp fry *Cyprinus carpio* L. (in 1964-1971). Roach spawners, common bream fry and crucian carp *Carassius* sp. and eel *Anguilla anguilla* (L.) fry were released sporadically. The absence of catches in some years did not influence the average yield of the time periods compared

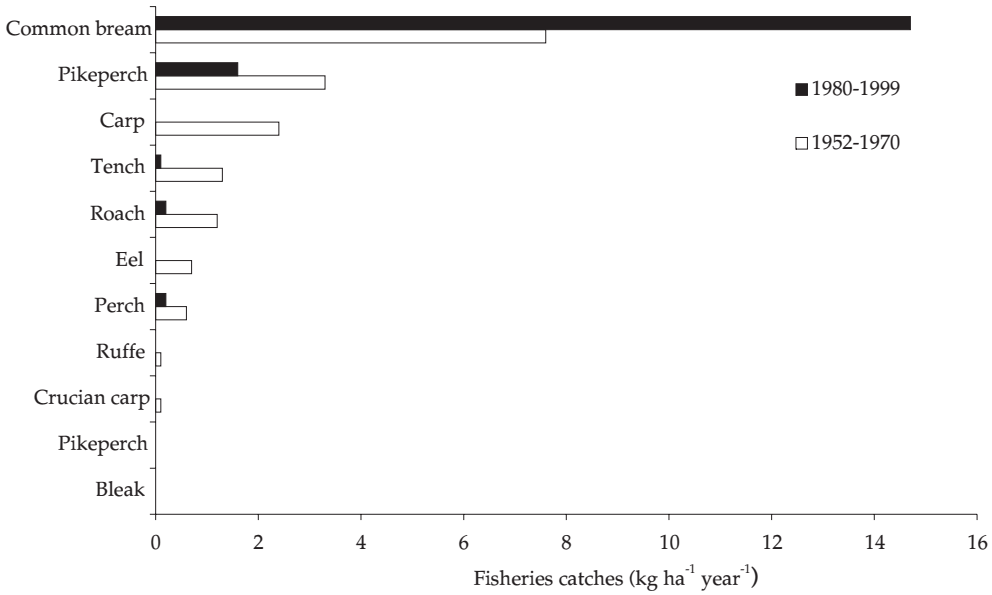

Fig. 3. Contribution of particular species in fisheries catches in Lake Dołgie Wielkie in 1952-1970 and 1980-1999.

($t = 0.0064$, $P > 0.05$). The fisheries catches were an average of 17.1 and 16.7 kg ha^{-1} $year^{-1}$ (Fig. 3). During the first time period, the catches were supported by five fish species (almost 92% of biomass of the fish caught), while in the second period two species dominated and constituted 97% of the fish biomass.

DISCUSSION

The small number of fish species caught in the littoral of Lake Dołgie Wielkie contrasts with their abundance in the nearby Gardno and Łebsko lakes, which are large lakes on the Polish scale. Rivers and numerous canals flow into these lakes, and their permanent connection with the sea means that the habitat is good for many marine fish species which prefer freshwater, rheophilous ecosystems as well as for escapees from cultivation facilities (Sobocki 2002). The permanent connection between Lake Dołgie Wielkie and the Gardno – Łebsko canal allows fish to migrate within this sys-

tem. The lack of belica in the Gardno and Łebsko lakes is an interesting observation (Ciepielewski 2002). This phenomenon can be explained either by the fact that data regarding species composition are most often derived from catch statistics and belica is not reported, or because this species avoids brackish waters. It does not occur in the Szczecin Lagoon either (Psuty-Lipska and Garbacik-Wesołowska 1998).

The results of the fry trawl catches did not confirm the occurrence of the species reported in the lake log books, including species such as eel, tench *Tinca tinca* (L.), crucian carp, bleak *Alburnus alburnus* (L.), pikeperch and carp. The absence of some of them can be attributed to the cessation of stocking (carp, pikeperch), the limited number of eel which enter Polish Baltic Sea coastal waters or the poor catchability of the gear applied with regard to some species. The extinction of tench and crucian carp in Gardno and Łebsko lakes was observed in the late 1970s (Sobocki 2002).

In spring age group 1+ fish dominated the littoral catches and older specimens were rare. Fry dominated the catches beginning in June. Similar relationships were reported for fish assemblages in stagnant areas of the central Vistula River (Backiel 1958) and in the heated Licheńskie Lake where hatch appeared as soon as in April and in late May and early June the contribution of fish from age group 0+ exceeded 90% (Wilkońska and Żuromska 1977). Differences in the timing of the appearance of juvenile fish and the peak of their abundance between Lake Dołgie Wielkie and Licheńskie Lake are the result of varied thermal conditions in the two basins. Belica was the most common of all the fish species caught. Although the abundance of perch was four-fold lower than roach, it was still present in a greater number of hauls. This suggests that perch forms less numerous concentrations that are scattered throughout different parts of littoral, while roach occurs in larger assemblages which are limited to certain zones of the lake. It is characteristic for there to be a certain degree of coherence in the comparison of the availability of fry and that of fish from older age groups. Of the species for which these two age groups were caught, only perch fry was more common than older specimens. This is due to the older perch specimens leaving the shallow littoral and to the sampling method used. The distance at which larger fish react to an approaching person is greater (Frankiewicz et al. 1986).

The distribution of the contribution of particular species, with very high belica abundance and low numbers of them in the lake littoral, meant that the coefficient of species diversity was low. In multi-species assemblages the *D* coefficient has greater values when one species is not clearly dominant (Ricklefs and Miller 2000). The diversity of environments within a lake provides good conditions for the creation of spa-

tially diverse fish assemblages (Benson and Magnuson 1992). Thus, the littoral of Lake Dołgie Wielkie is not very diverse and its ichthyofauna is dominated by belica.

The fisheries efficiency in Lake Dołgie Wielkie is similar to that of other coastal lakes with a low level of water exchange with the sea, but it is much higher in comparison to other lobelia-lakes (Kraska et al. 1996, Heese 1998, 2000). The structure of the contribution of the various species in the commercial catches is different than in other lobelia-lakes in western Pomerania and similar to that in coastal lakes. The ichthyofauna of Lake Dołgie Wielkie can be classified as a eutrophic fish assemblage which occurs in lobelia lakes (Heese 2000).

Changes in lakes are often concerned with progressing eutrophication. Increased trophic conditions in basins influence the species composition of fish assemblages (Leopold et al. 1986), while fish have a strong impact on the structure and functioning of aquatic ecosystems (Opuszyński 1987, Northcote 1988). The fisheries conducted in the lake in the second half of the twentieth century were based on stocking, and although stocking was not systematic, it nevertheless had a certain impact on the ichthyofauna. Intensive carp stocking influenced the structure of the ichthyofauna, which then had an impact on the functioning of the ecosystem; this species obviously had an impact on water transparency and chemistry. A large area of Lake Dołgie Wielkie bottom is covered with soft, sapropel sediments. While benthivorous fish feed, these sediments are resuspended and water transparency is lowered. These fish indirectly increase nutrient circulation and increase the abundance and biomass of phytoplankton which is the most obvious symptom of eutrophication (Opuszyński 1987). Currently, carp, which is a foreign species in this lake, has retreated due to the lack of spawning grounds; however, low water transparency is still noted. Stopping stocking did not affect the average number of fish caught, but it did result in the ichthyofauna composition becoming poorer.

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STRESZCZENIE

CHARAKTERYSTYKA STRUKTURY ZESPOŁÓW ICHTIOFAUNY W LITORALU LOBELIOWEGO JEZIORA DOŁGIE WIELKIE ORAZ ANALIZA ODŁOWÓW RYBACKICH

Celem badań była charakterystyka składu gatunkowego zespołów ryb strefy litoralowej i analiza statystyk odłowów dokonywanych w lobeliowym jeziorze Dołgie Wielkie. Jest ono położone w bezpośrednim sąsiedztwie Morza Bałtyckiego, pomiędzy jeziorami Gardno i Łebsko, na terenie Słowińskiego Parku Narodowego (rys. 1). Połowy ryb przeprowadzono przy użyciu włoczka tiulowego w okresie od maja do sierpnia 2001 roku, w strefie płytkiego litoralu. Wraz z odłowem ryb rejestrowano temperaturę, widzialność krążka Secchiego oraz okresowo zawartość tlenu rozpuszczonego w wodzie (rys. 2). Przeanalizowano również odłowy komercyjne prowadzone w latach 1952-1970 i 1980-1990 (rys. 3). Złowiono ryby 9 gatunków, w większości (81,1%) należących do stadiów młodocianych (tab. 2). Największy udział (%) w zespole ryb litoralowych osiągnęła słonecznica, która również charakteryzowała się najwyższym wskaźnikiem dostępności (tab. 3). Niewielka liczba gatunków w zespole ryb jeziora i rozkład częstości ich występowania zadecydowały o niskiej wartości współczynnika różnorodności gatunkowej Simpsona (D), który wyniósł 0,2082. Litoral jeziora Dołgie Wielkie jest mało urozmaicony, a pod względem składu ichtiofauny zdominowany przez słonecznicę. W porównaniu z jeziorami lobeliowymi Pomorza Zachodniego jezioro Dołgie Wielkie wyróżnia się odmienną strukturą udziału poszczególnych gatunków w odłowach komercyjnych oraz wyższą wydajnością rybacką. Zespół ryb zamieszkujących ten zbiornik można zaliczyć do charakterystycznego dla jezior eutroficznych.

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