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Evolution of fish fauna in Little Balaton Water Reservoir

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Introduction

The first stage of Little Balaton Water Reservoir (18 km^2) was constructed and impounded in 1985 in order to remove the phosphorus and to silt the sediments carried by the River Zala into the SW-basin of Lake Balaton. In the shallow reservoir (1.14 m), the water residence time is ca. 40 days and the phosphorus loading is high: 5 g · m^{-2} · yr^{-1}. The amount of nitrogen carried by River Zala may reach 6 g · m^{-3}, and the total phosphorus content varies from 0.1 to 2.0 · m^{-3}. The chlorophyll *a* concentration usually remains below 20 mg · m^{-3}, however, the humus content in the sediment is high: around 350 mg · g^{-1}. At central parts of the reservoir the summer chlorophyll *a* concentration during blue-green blooms may reach 400 mg · m^{-3}. Reed-grass stands cover about 50 % of the water surface, having a mean biomass of about 3.3 kg · m^{-2}. The reservoir annually retains a high amount of nutrients (total-P: 92–105 t · yr^{-1}; total-N: 1071–1097 t · yr^{-1}) in about 60 ± 15 % efficiency (Szilágyi et al. 1990).

Trends in fish fauna formation, the occurrence, habitat characteristics, dynamics and stock-size of different fish species have been studied since 1986 up to the present. Results of extensive studies are briefly summarized here.

Study area and methods

Fish collections were made monthly with electric shocker at four areas during 1988–90 (Fig. 1). In 1988 six northern rivulets, inflowing into Lake Balaton, while in 1989 nine southern ones were also studied. In 1990 two additional rivulets connected with the reservoir were checked. In each occasion about 0.1–0.2 ha of water surface were fished. Following species determination, length and weight were measured, and length/weight relationships were calculated. Age and growth were esti-

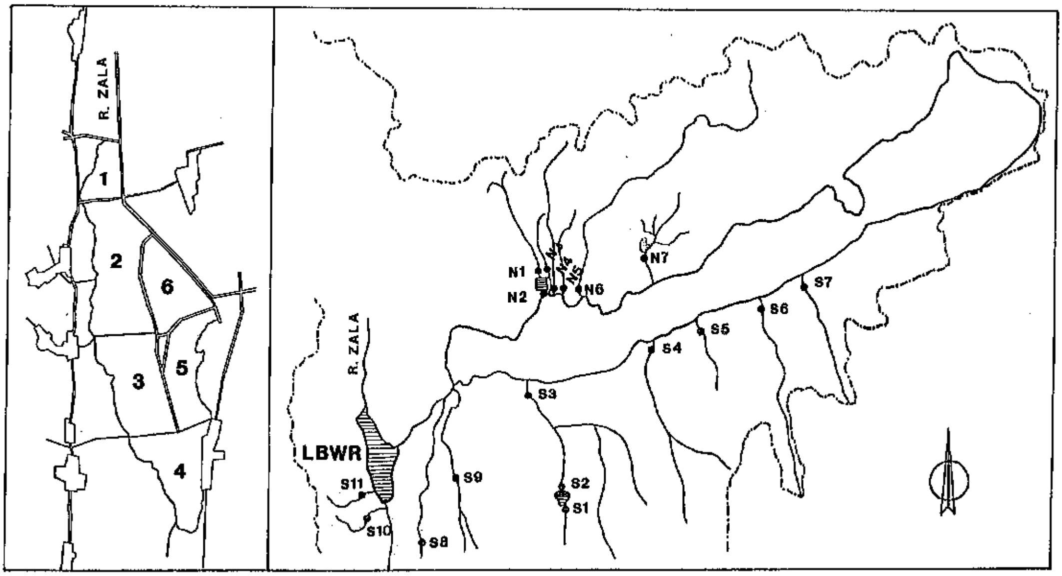

Fig. 1. Map of the area studied. N1–N7: sampling stations in northern inflows, S1–S11: sampling stations in southern inflows. Areas of Little Balaton Water Reservoir (LBWR) (enlarged at left) # 1 = 84.5 ha, # 2 = 382.8 ha, # 3 = 258.3 ha, # 4 = 345.4 ha, # 5 = 201.2 ha, # 6 = 283.8 ha).

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Table 1. List of species occurring in Little Balaton Reservoir and inflowing waters of Lake Balaton.

No.	Species	LB	LBWR	NI	SI
1.	European mud-minnow – *Umbra krameri**	–	–	+	+
2.	Pike – *Esox lucius*	+	+	+	+
3.	Roach – *Rutilus rutilus*	+	+	+	+
4.	Amur – *Ctenopharyngodon idella*	+	–	–	+
5.	Rudd – *Scardinius erythrophthalmus*	+	+	+	+
6.	Chub – *Leuciscus cephalus*	–	–	+	+
7.	Ide – *Leuciscus idus*	–	–	–	+
8.	Asp – *Aspius aspius*	+	+	+	–
9.	Bleak – *Alburnus alburnus*	+	+	+	+
10.	White bream – *Blicca bjoerkna*	+	+	+	+
11.	Bream – *Abramis brama*	+	+	+	+
12.	Tench – *Tinca tinca*	+	+	+	+
13.	Gudgeon – *Gobio gobio*	+	+	+	–
14.	Long-whiskered gudgeon – *Gobio uranoscopus**	–	–	–	+
15.	Rasbora – *Pseudorasbora parva*	+	+	–	+
16.	Bitterling – *Rhodeus sericeus amarus*	+	+	+	+
17.	Crucian carp – *Carassius carassius*	+	+	+	+
18.	"Giebel" – *Carassius auratus gibelio*	+	+	+	+
19.	Carp – *Cyprinus carpio*	+	+	–	+
20.	Silver carp – *Hypophthalmichthys molitrix*	+	+	–	+
21.	Stone loach – *Noemacheilus barbatulus**	+	+	–	+
22.	Weatherfish – *Misgurnus fossilis**	+	+	+	+
23.	Spined loach – *Cobitis taenia**	+	+	–	
24.	Wels – *Silurus glanis*	+	+	–	+
25.	Eel – *Anguilla anguilla*	+	+	+	+
26.	Pumpkinseed – *Lepomis gibbosus*	+	+	+	+
27.	Perch – *Perca fluviatilis*	+	+	+	+
28.	Ruffe – *Gymnocephalus cernuus*	+	+	+	+
29.	Pikeperch – *Stizostedion lucioperca*	+	+	+	+
30.	Wolga pikeperch – *Stizostedion volgensis*	+	–	–	+
31.	Monkey goby – *Neogobius fluviatilis**	+	+	–	+
Total number:		27	25	20	29

LB = Lake Balaton.
LBWR = Little Balaton Water Reservoir.
NI = Northern inflows.
SI = Southern inflows.
* = protected species.

mated according to annual markes of the scales. Rates of total mortality (Z), survival (S), annual mortality (A) were assed from the number of certain species belonging to different age-groups. Rate of growth in weight (G), mean biomass ($\bar{B}$), production (P) as well as P/$\bar{B}$-ratio have also been calculated (Bíró et al. 1990, Ricker 1975).

During September–November 1991, collectings were made biweakly at six different areas of Little Balaton Reservoir in order to control the species distribution (density) and to assess their biomass (Fig. 1). The biomass (standing stock) of economically important fish species was estimated according to their number caught from the fished area and multiplied by their mean weight. Stock density and biomass were then converted to unit of area (ha).

Construction of the second stage of Little Balaton Reservoir started in 1992 and the formation of its fish fauna has recently been studied.

Results

Formation and alteration of species assemblages

During the whole period of investigations (1988–91) altogether 31 fish species occurred in the reservoir and inflowing waters (Table 1). In 1988 a total of 1302 specimens belonging to 20 species were collected from the reservoir and River Zala, where

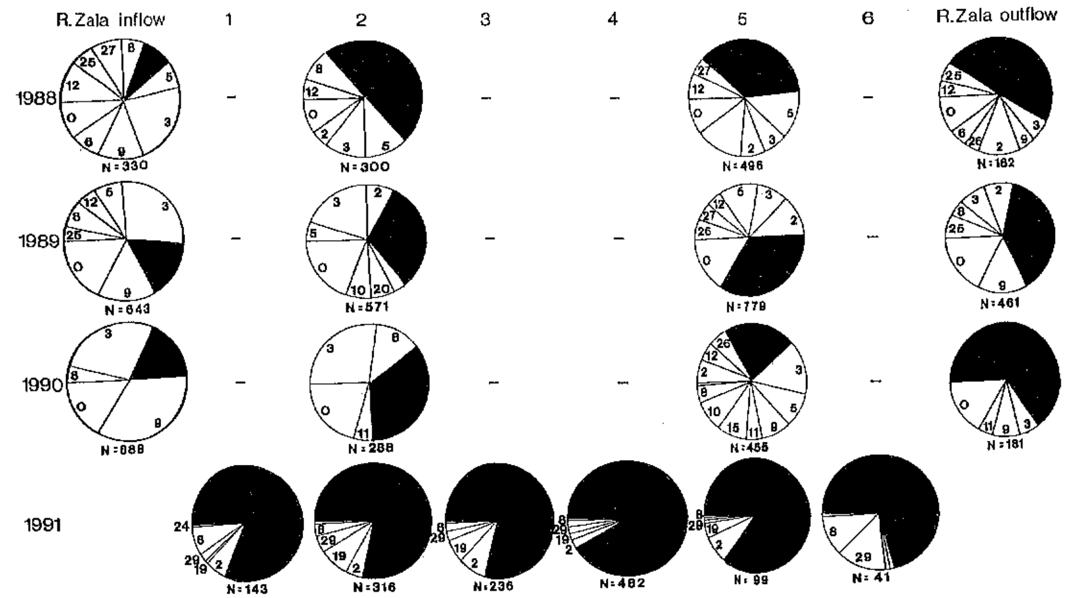

Fig. 2. Frequency of occurrence (%) of different fish species in River Zala and at areas 1–6 of LBWR during 1988–91. Numbers in the segments refer to the serial number of species in Table 1. Black segments are of *Carassius auratus gibelio*. O = others.

cyprinids dominated. Soon after the impoundment of the reservoir (1985) the explosion-like appearance of pike (*Esox lucius*) and "Giebel" (*Carassius auratus gibelio*) was observed, and their population density during 1988 started to stabilize. In 1989 altogether 2454 specimens (24 species), in 1990 altogether 888 individuals (14 species) were collected. Cyprinids dominated all the time, and the percentage composition of fish assemblages resembled to that of Lake Balaton. In 1991 "Giebel" dominated all over the reservoir (Fig. 2).

Fish fauna of inflowing waters

Species number (20) in six northern rivulets varied from 6 to 13 including 1–2 rare or endangered species. In nine southern rivulets of Lake Balaton and Little Balaton Reservoir the species number (29) ranged from 1 to 15 with the occurrence of 1–3 threatened (protected) species (Fig. 3). *Carassius auratus gibelio* occurred only in southern inflows. The mosaic-like pattern of distribution of rare and endangered (protected) species indicate that the inflowing waters serve as *refugia* for them, where they have self-sustaining stocks. Most of them probably emigrated from Lake Balaton to these refugia in consequence of advanced eutrophication of the lake and of other human impacts.

Changes in biomass and dynamics of fish stocks

Estimated mean biomass ($\bar{B}$), production (P) and P/$\bar{B}$-ratio of the most common cyprinids (1988) varied widely. The P/$\bar{B}$-ratio seemed to vary inversely to their population density. In roach AG 1+–3+) 128.6%, in bream (AG 1+–2+) 91.9%, in bleak (AG 0+–2+) 56.4%, in "Giebel" (AG 0+–4+) 68.8% and in carp (AG 2+–4+) 51.2% was estimated, respectively. The growth rate of species studied was faster than those in Lake Balaton and varied at different areas of the reservoir. Rates of mortality and survival varied in different age-groups of species at various areas. Total fish density changed during 1988–90 at area # 2 as 245, 305 and 245 ind · ha^{-1}, and at area # 3 as 432.5, 455 and 302.5 ind · ha^{-1}, respectively.

In 1991, the stock sizes (standing stock) of economically most important six species were estimated at six different areas of the reservoir (Table 2). An increasing gradient of total fish density in successive areas has been observed which varied from 124.8 to 609.3 ind · ha^{-1} or from 66.9 to 296 kg · ha^{-1} (values for area # 6 are irreal, because a massive mortality of *C. auratus gibelio* (100–150 tonnes) took place in 1990–91). The increasing trend of fish density was especially explicit in "Giebel". Expressing the biomass values at different areas (# 1–6) for the whole surface of

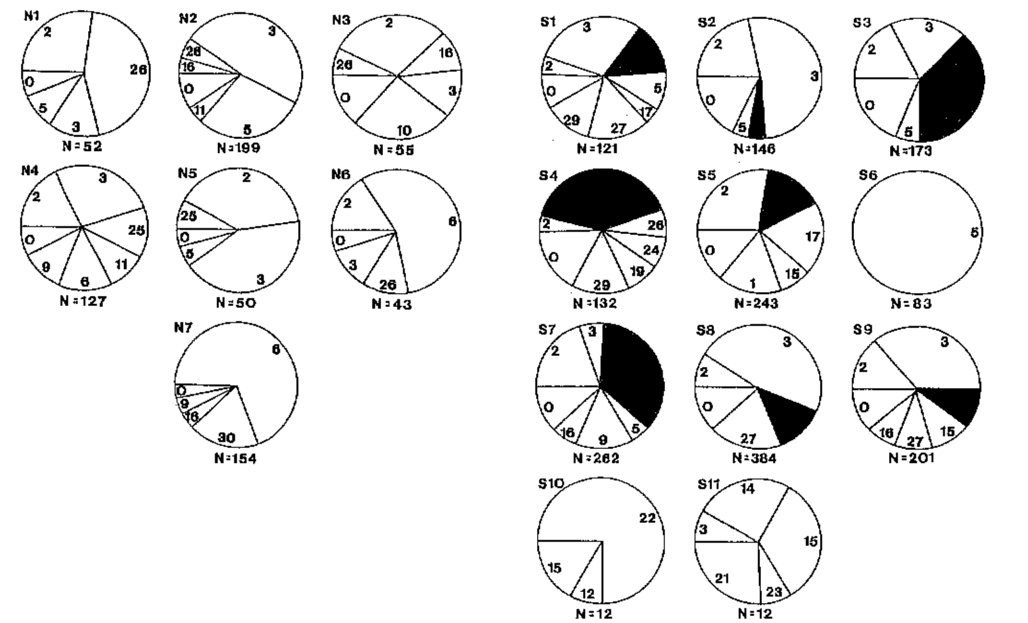

Fig. 3. Frequency of occurrence (%) of different fish species in northern (N1–N7) and in southern (S1–S11) inflows (see Fig. 2).

the reservoir, a total of 265 tonnes were obtained that means an average biomass of 170.3 kg · ha^{-1} (66.8–296 kg · ha^{-1}) (Table 2).

Exploitation

Commercial fisheries were authorized in the lower ⅔ of the reservoir (ca. 800 ha) with use of 100 m long gill-nets as well as traps. Annual yields of 12 different species during the successive years (1988–91) showed a decreasing tendency between 12.785 to 2.888 kg · ha^{-1} (10.228–2.31 tonnes · $year^{-1}$). These figures refer to an underexploitation of the fish stocks, because the carrying capacity of the reservoir is much higher. Although there is an increasing tendency of sport fisheries (number of licences sold during 1990–91 varied from 10,500 to 16,480 per year), no correct catch statistics are available, therefore the impact of sport fisheries cannot be evaluated.

Discussion

Trends in fish fauna composition of LBWR showed some stabile colonization by omnivorous nonguarding ecological guilds (Balon 1975) represented by open water substratum phytolithophils (Cyprinidae, Percidae) (Fernando & Holčík 1991). Formation of fish fauna of LBWR was closely related to the immigration (translocation) of certain species mainly from southern rivulets of Lake Balaton (Bíró et al. 1990). Low species and high individual numbers in six northern inflows indicate low diversity (3 groups according to Czekanowski; C_z = 0.38–0.56). In the reservoir C_z = 0.58, while the nine southern inflows can be grouped into 6 similarity groups (C_z = 0.14–0.44) (Bíró et al. 1990).

Tendency of enhanced invasion in LBWR by *Carassius auratus gibelio* (and in Lake Balaton itself) indicates a long-lasting ecological impact from this species through the alteration of the trophic relationships (sharpening intra- and interspecific competition).

Habitats of rare and endangered species should be strictly protected in order to preserve their self-sustaining (isolated) stocks from any human impacts.

Estimated population density and stock size (biomass) indicate that LBWR has been a highly productive water area. Fish biomass per unit of area was two-four times higher than in Lake Balaton. Comparing the measured gross primary productivity of LBWR (22,279.8 kJ · m^{-2} · $year^{-1}$) (calculated from data by Pomogyi 1990) to the fish yield (1.2–5.35 kJ · m^{-2} · $year^{-1}$), a fairly low efficiency of energy transfer of primary producers to fish could be obtained: 0.0053 – 0.024 % (LeCren & Lowe-McConnell 1980). This rough estimate suggest that an "overshoot" in primary production is coupling with a reduced efficiency of fish production and the energy dissipates significantly within the ecosystem.

Fish carrying capacity of the reservoir shows an extremely high value, but repeated massive fish-kills indicate that LBWR has been overpopulated by fish and underexploited by commercial and sport fisheries (Bíró et al. 1990).

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References

Bíró, P., Paulovits, G. & P. Ebesfalvi, S., 1990: A Kis-Balaton Védörend-szer és csatlakozó vízgyüjtö vizeiben a halállomány (különös figyelemmel a ritka és veszélyeztetett halfajokra) feltárása és a gazdasági hasznosítás lehetöségei-nek megismerése. – Környezetgazdálkodási kutatások 5. A G-10 jelü OKKET Program keretében végzett balatoni kutatások. TREND Kft. Budapest, 152–184.

Fernando, C. H. & Holčík, J., 1991: Fish in Reservoirs. – *Int. Revue ge. Hydrobiol.* 76 (2): 149–167.

Le Cren, E. D. & Lowe-McConnell, R. H., 1980: The functioning of freshwater ecosystems. – *IBP Handbook* 22. Cambridge, 588 pp.

Pomogyi, P. (ed.), 1991: A Kis-Balaton Védörendszer kémiai, biológiai, anyagforgalmi vizsgálatai (1985–90). – NYUDUVIZIG, Szombathely-Keszthely, 258 pp.

Ricker, W. E., 1975: Computation and interpretation of biological statistics of fish populations. – *Bull. Fish. Res. Bd. Canada* 191, 382 pp.

Szilágyi, F., Somlyódy, L. & Koncsos, L., 1990: Operation of the Kis-Balaton reservoir: evaluation of nutrient removal rates. – In: Bíró, P. & Talling, J. F. (eds.): *Trophic Relationships in Inland Waters:* 297–306. – Developments in Hydrobiology 53. Kluwer Acad. Publ. Dordrecht–Boston–London.

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