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S. Georgiev: Fish in the Mavrovo Reservoir

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SUCCESSION AND STRUCTURE OF THE FISH IN THE MAVROVO RESERVOIR (THE REPUBLIC OF MACEDONIA)

S. Georgiev

Summary

Hereby are presented some ecological features of the fish inhabiting the Mavrovo Reservoir, one indigenous and six brought in; *Salmo trutta* (Linnaeus, 1758), *Oncorhynchus mykiss* (Walbaum, 1796), *Leuciscus cephalus* (Linnaeus, 1758), *Pachychilon pictum* (Heckel & Kner, 1858), *Phoxinus phoxinus* (Linnaeus, 1758), *Barbus peloponnesius* Valenciennes, 1844 and *Alburnus alburnus* (Linnaeus, 1758). The *Ph. phoxinus* species has disappeared in the course of the investigation. The most commonly found population is *A. alburnus,* followed by the *P. pictum*, an endemic species for the watershed and a benthal one, as the *B. peloponnesius* is. *L. cephalus* when young is a littoral and a free–swimming fish, and when adult it becomes benthal. The population of the indigenous *S. trutta* is devastated. Data on the condition coefficient, the l–w relationship, the coefficient of the maturity, nutrition, shows that all the species, with exception to the *Ph. phoxinus* that disappeared, enjoy favorable ecological conditions, in spite of the height of the reservoir of about 1233 m above the sea level and the harsh climate conditions during the winter time.

Key words: *Mavrovo Reservoir, Macedonia, fish ecology,* Salmo trutta, *limnetic habitat, Nacional Park, introduction.*

INTRODUCTION

The Mavrovo reservoir was created in 1953 with the aim to collect water for power production (Sidorovski, 1955). For this purpose, a 98–meter high dam was constructed on the Mavrovska Radika stream, enriched by the waters

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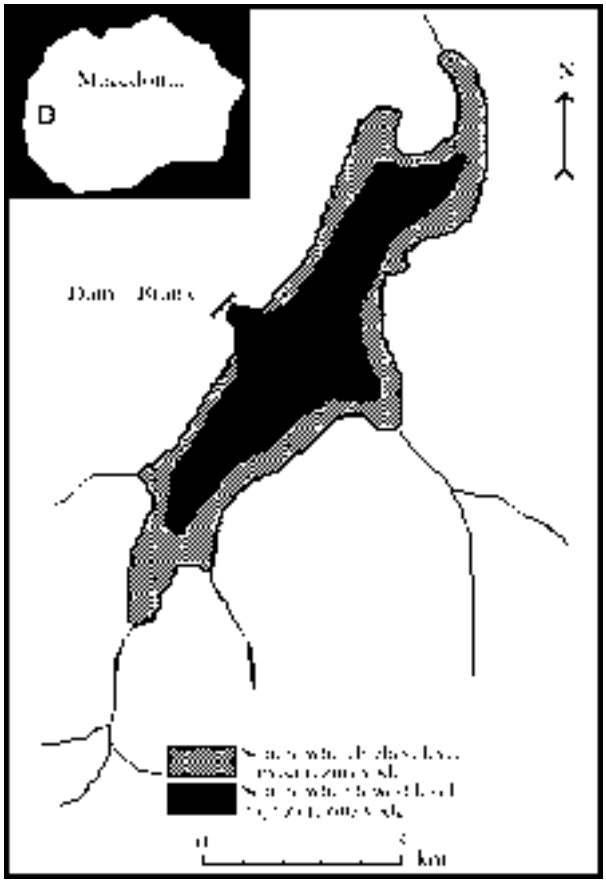

Figure 1. The Mavrovo Reservoir, form and position in the state.
Slika 1. Mavrovska akumulacija, oblik te položaj u državi.

of some other brooks in the upper part of the Radika River, Bojana/Drim system and Adriatic Sea watershed. Later on, the water from some neighboring brooks, the Vardar river flow, Aegean Sea watershed, was also led through channels and tunnels (Georgiev and Cilevski, 1991). The level of the reservoir varies by 26 meters, and when highest it covers a surface of 12 km^2 (Figure 1), and volume of $340*10^6 m^3$ (Sidorovski, 1955).

The indigenous population of fish was monotypic for three decades, consisting only of the indigenous *S. trutta* that lived in the brooks that went across the Mavrovsko Pole plain, submersed and transformed in limnetic habitat. There are several investigations on the *S. trutta* population from this period (Karaman, 1957; Sidorovski, 1955, 1960, 1971; Popovska — Stanković and Georgiev, 1973; Apostolski, 1976), as well as on the community of the invertebrates from the new habitat (Stojkovski, 1960; Popovska — Stanković, 1963).

In the early 1980's the first information from the anglers showed that other fish besides the *S. trutta* were caught. In addition, the cages for raising of *O. mykiss* were installed for commercial reasons. The implantation of other fish species in the Mavrovo Reservoir was against the law, because the area was declared a National Park and the introduction of outside genetic material was prohibited. The information collected on the origin of the cyprinid species (*A. alburnus*, *B. peloponnesius*, *L. cephalus*, *P. pictum*, *Ph. phoxinus*) show that they had been implanted from the Ohrid Lake, the same watershed. The natural ecologic barrier for invasion of those fish from the Ohrid Lake in the streams crossing the Mavrovo Plain before the dam construction was the salmonid stream of the Radika River whose last ten kilometers of stream are inhabited by *L. cephalus*, *A. alburnus* and *Chondrostoma nasus* (Linnaeus, 1758), the last of those is not to be found in the Mavrovo Reservoir. There is only one paper about the new fish assemble after this implantation (Georgiev and Cilevski, 1991).

The reservoir is situated in the western part of Republic of Macedonia, a twenty km distanced, by air line, from the highest peak on the West Balkan Peninsula Dinarids–Heleneids chain, which is the Korab peak at 2764 m (Arsovski, 1997), and it is surrounded by mountains high from 1700 to 2100 m in area with harsh mountainous climate, where starting from the end of December until mid April it is ice–capped. The form of the reservoir is elongated in the Northeast–Southwest direction.

TAXONOMICAL REMARKS

The taxonomy of the examined fish was determined according the key of Vuković and Ivanović (1971). For some fish from the *Salmo* genus mentioned in the References, listed also by Kottelat (1997): *Salmo farioides* Karaman, 1938, *Salmo letnica* Karaman, 1924=*Salmo aphelios* Kottelat, 1997, the name *Salmo trutta* (Linnaeus, 1758), is used on the bases of the work of Bernatchez (2001). The name *B. peloponnesius* according Kottelat (1997), is used instead of the name *Barbus meridionalis* Risso, 1826, in Vuković and Ivanović (1971).

MATERIAL AND METHODS

The material was collected from the spring of 1991 until the autumn of 1995. After 1993, no *Ph. phoxinus* samples were caught so it was concluded that this species has disappeared from the reservoir.

The fish were caught by pendent standing nets with different eye diameters in different parts of the lake, due to the variation of the level and the surface, so that the endings of the north and south points of the reservoir move in total for approximately 1 km; hook; some pieces were provided by

the anglers. Even at the lowest level and the smallest surface, the depth of the reservoir never goes below 30 m; the water quantity in the reservoir when the level is lowest is 1/3 of the water quantity present when the level is highest, and it freezes earlier or later depending on the year due to the different level/quantity of the water. The fish were fixed in the 4 % phormaldehyde solution and processed in the laboratory. The fork length was measured with 1 mm precision for the fish up to 20 cm long and with 5 mm precision (0, 5 cm) for the fish longer than 20 cm. The mass of the fish below 1 g was weighed on the electronic balance with 0,0001 g precision, as well as the gonads fecundity samples pieces. The stadium of the gonads has been macroscopically determined on the universal scale of Nikolsky (1963). The condition coefficient was calculated according the equation of Foolton $K=100*W/L^3$ (Rounsefell and Everhart, 1953), the length–weight relationship according the equation $W=c*L^n$, the maturation coefficient according the equation F=wg*100/w (Petrovski, 1960), the absolute and relative fecundity by counting the number of roe sample in relation to the weight of the ovarian, of the body and in 1 kg of mass. The taxonomy of the food compounds has been determined for the order, rarely for a family, and only by exception for genus. The identification manuals: Fott (1971); Lazar (1960), Zhadin (1948); Bertrand (1954); Edington and Hidrew (1981); Vuković and Ivanović (1971); Kottelat (1997) were used. The item calculated was the percent of fish that consumed the main food constituents.

For one specimen it was stated to represent a hybrid between *A. alburnus* and *L. cephalus*; for two females of *A. alburnus* it was stated that are invaded by the *Ligula intestinalis* parasite; four samples also of *A. alburnus* species were stated to be sterile. Those specimens were not included in the calculation of the results. It was stated that the intestines of many of the specimens of the *L. cephalus* species were invaded by parasites, but this was not in line with the interest of the project proposal, and therefore their taxonomic belonging and extension were not subject to study.

Scales were taken from each weighted fish for determination of the age.

RESULTS AND DISCUSSION

As it can be seen in Table 1, a total of 1067 specimens were on disposition, which were not equally distributed for each species. While the presence of the native *S. trutta*, *Ph. phoxinus*, *B. peloponnesius* and *O. mykiss* is symbolic, the presence of *L. cephalus* and *P. pictum* is satisfactory, and the participation of *A. alburnus* is far more abundant than of all the other species together. One thing that needs to be pointed out is that most of the samples of *S. trutta*, concluding from their phenotype, originate from the reservoir, starting their life as alevins in the reservoir, but some also, which according the scales were aged as 3+ or 4+, have shown the lotic phenotype, which means that they have recently entered the reservoir from its confluents and which is even more

surprising because they were caught during the spawning period, which is contradictory to the theoretical and empiric experience of matured fish to migrate in the confluents of the reservoir to spawn there. This, as well as the fact that a very small number of this species were caught, states that the population of this sole indigenous fish species is hardly decreased due to the unreasonable fishing with nets that is prohibited, a situation frequently present for a long time in many countries in Eastern Europe (Drobnjaković, 1934; Orešarov and Niškov, 1959; Janković and Raspopović, 1960).

Table 1. Collected fish species and years during the investigation.
Tablica 1. Sakupljene vrste riba po godinama tijekom istraživanja.

Year / Godina	month, n / mjesec, n												Total
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
S. trutta													
1992	.	.	.	2	.	.	.	1	.	.	6	5	*14*
1993	.	.	.	.	.	1	.	.	.	1	.	.	*2*
	—	—	—	*2*	—	*1*	—	*1*	—	*1*	*6*	*5*	**16**
A. alburnus													
1991	.	.	.	.	10	11	43	8	14	16	1	16	*119*
1992	15	.	.	.	12	25	28	18	18	.	.	.	*134*
1993	.	.	.	.	7	36	22	22	16	61	.	.	*164*
1994	.	.	.	.	46	30	26	39	37	22	.	.	*200*
1995	.	.	.	.	17	31	20	.	.	.	.	.	*68*
	15	—	—	—	*92*	*133*	*139*	*87*	*85*	*99*	*1*	*16*	**685**
L. cephalus													
1991	.	.	.	4	.	7	1	9	.	1	.	10	*22*
1992	.	.	.	.	2	5	7		1	.	.	.	*15*
1993	.	.	.	.	24	16	14	14	47	.	.	.	*115*
1994	.	.	.	.	7	7	5	5	7	5	1	.	*37*
1995	.	.	.	.	25	.	.	.	.	.	.	.	*25*
	—	—	—	*4*	*58*	*35*	*27*	*28*	*55*	*6*	*1*	*10*	**214**
P. pictum													
1991	.	.	.	12	1	.	.	.	.	1	.	12	*26*
1992	.	.	.	.	2	2	.	7	1	5	.	.	*17*
1993	.	.	.	.	4	3	.	1	.	2	.	.	*10*
1994	.	.	.	.	.	.	4	1	38	1	.	.	*44*
1995	.	.	.	.	1	.	.	.	.	.	.	.	*1*
	—	—	—	*12*	*8*	*5*	*4*	*9*	*39*	*9*	—	*12*	**98**

cont. Table 1 — nastavak Tablice 1

O. mykiss													
1991	.	.	.	8	.	.	.	.	4	1	13	.	*26*
1992	.	.	.	.	2	.	.	.	.	1	.	.	*3,*
1993	.	2	1	.	4	.	.	.	.	.	.	.	*8*
	—	*2*	*1*	*8*	*6*	—	—	—	*4*	*2*	*13*	—	**37**
B. peloponnesius													
1991	.	.	.	3	.	.	.	.	.	.	.	.	*3*
1992	.	.	.	.	.	.	1	.		.	.	.	*1*
1993	.	.	.	.	.	1	.	.	1	.	.	.	*2*
1994	.	.	.	.	.	1	1	.		.	.	.	*2*
	—	—	—	*3*	—	*2*	*2*	—	*1*	—	—	—	**8**
Ph. phoxinus													
1991	.	.	.	.	.	.	.	2	.	.	.	.	2
1992	.	.	.	.	2	.	2	.	.	.	.	.	4
1993	.	.	.	.	.	.	.	.	3	.	.	.	3
	—	—	—	—	2	—	2	2	3	—	—	—	**9**
Σ													**1,067**

Table 2. L–w relationship and equations received to for S. trutta, L. cephalus, P. pictum *and* O. mykiss.
Tablica 2. Suodnos duljina–masa i dobivene jednadžbe za S. trutta, L. cephalus, P. pictum *i* O. mykiss.

Length class		L Dužina x	W Težina x	Counted w Izračunana težina	Difference among the real and counted w Razlika između stvarne i izračunane težine	
cm	n	cm	g	g	g	%
S. trutta				**log w=2.95503*log l –3.9488**		
00.1–10	1	9.10	14.50	13.01	–1.48	**–11.39**
10.1–20	3	19.50	106.50	123.32	+16.82	**+13.64**
20.1–30	4	24.75	226.75	249.19	+22.44	**+9.00**
30.1–40	3	35.00	730.00	692.66	–37.34	**–5.39**
40.1–50	4	43.25	1352.50	1293.33	–59.17	**–4.57**
50.1–60	2	56.50	2950.00	2845.29	–104.71	**–3.68**
L. cephalus				**log w=2.9742786*log l –3.9384671**		
1.1–4	31	2.99	0.52	0.51	+0.01	**+2.73**

cont. Table 2 — nastavak Tablice 2

4.1–7	31	5.15	2.50	2.55	–0.11	**–4.42**
7.1–10	46	8.96	12.81	13.24	–0.43	**–3.27**
10.1–13	60	11.48	28.61	27.68	+0.93	**+3.37**
13.1–16	16	13.96	51.02	49.52	+1.50	**+3.03**
16.1–19	14	18.24	116.67	109.69	+6.97	**+6.36**
19.1–22	23	20.56	145.56	156.62	–11.07	**–7.06**
P. pictum				**log w=3.2653918*log l –4.4414466**		
0.1–2	4	16.5	0.05	0.06	+0.01	**+1.26**
2.1–4	9	27.9	0.39	0.33	–0.05	**–16.25**
4.1–6	1	46.0	2.00	1.72	–0.28	**–16.35**
6.1–8	13	74.1	8.32	8.17	–0.15	**–1.80**
8.1–10	31	89.9	14.61	15.34	+0.73	**+4.79**
10.1–12	19	112.3	31.73	31.71	–0.01	**–0.05**
12.1–14	17	131.6	52.99	53.23	+0.24	**+0.44**
14.1–16	6	148.0	72.26	78.07	+5.81	**+7.44**
O. mykiss				**log w=3.18966*log l –4.7246**		
15.1–20	2	19.75	117.50	120.38	–2.88	**–2.39**
20.1–25	4	23.65	222.30	213.89	+8.41	**+3.93**
25.1–30	9	28.47	324.13	386.49	+7.65	**+1.98**
30.1–35	16	32.40	553.90	583.79	–29.88	**–5.12**
35.1–40	4	37.30	932.25	914.85	+17.40	**+1.90**

Table 3. L–w relationship and equations received to for A. alburnus.
Tablica 3. Suodnos duljina–masa i dobivene jednadžbe za A. alburnus.

Length class		L Dužina x	W Težina x	Counted w izračunana težina	Difference among the real and counted w Razlika između stvarne i izračunane težine	
cm	n	cm	g	g	g	%
Males / m				**log w=3.2110547*log l –4.7586624**		
6.1–7	4	6.65	3.62	3.76	+0.14	**+3.65**
7.1–8	19	7.64	5.96	5.88	–0.08	**–1.41**
8.1–9	43	8.64	8.90	8.71	–0.18	**–2.13**

cont. Table 3 — nastavak Tablice 3

9.1–10	64	9.48	11.94	11.76	–0.18	**–1.54**
10.1–11	46	10.63	17.66	16.96	–1.70	**–4.15**
11.1–12	29	11.53	21.55	22.05	+0.50	**+2.27**
12.1–13	8	12.42	27.15	28.00	+0.85	**–3.04**
females / ž			**log w=3.241324396*log l**			**–4.82682877**
6.1–7	5	6.94	4.40	4.27	–0.13	**–2.94**
7.1–8	29	7.67	5.78	5.91	+0.13	**+2.12**
8.1–9	44	8.62	8.31	8.63	+0.32	**+3.69**
9.1–10	47	9.56	11.91	12.07	+0.16	**+1.30**
10.1–11	64	10.56	17.47	16.66	–0.81	**–4.84**
11.1–12	91	11.61	23.23	22.66	–0.57	**–2.51**
12.1–13	50	12.54	29.07	29.08	+0.01	**+0.03**
13.1–14	11	13.44	34.68	36.41	+1.73	**+4.76**
14.1–15	1	14.10	43.40	42.53	–0.87	**–2.04**
juveniles / mlađ			**log w=3.281421277*log l**			**–4.85725112**
1.1–2	2	1.55	0.03	0.03	+0.00	**+8.37**
2.1–3	20	2.59	0.20	0.18	–0.02	**–12.18**
3.1–4	24	3.49	0.46	0.47	+0.01	**+1.41**
4.1–5	11	4.48	1.13	1.07	–0.06	**–6.13**
5.1–6	4	5.60	2.23	2.22	–0.06	**–0.70**
6.1–7	13	6.57	3.63	3.74	+0.12	**+3.12**
7.1–8	28	7.53	5.57	5.86	+0.30	**+4.95**
8.1–9	16	8.21	6.67	7.78	+0.10	**+1.35**
9.1–10	1	9.30	11.90	11.71	–0.19	**–1.63**
All the population / cijela populacija			**log w=3.241324396*log l**			**–4.82682877**
1.1–3	21	2.49	0.21	0.19	+0.01	**+7.01**
3.1–5	33	3.79	0.66	0.71	–0.04	**–6.02**
5.1–7	25	6.50	3.56	3.72	–0.17	**–4.49**
7.1–9	177	8.16	7.29	7.49	–0.20	**–2.69**
9.1–11	158	9.84	13.60	13.30	+0.29	**+2.21**
11.1–13	178	11.89	24.77	23.85	+0.92	**+3.84**
13.1–15	12	13.49	35.41	35.13	+0.28	**+0.80**

Length–weight relationship

The results of this study are shown in Table 2 for *S. trutta*, *L. cephalus*, *P. pictum* and *O. mykiss*, separately for *A. alburnus* in Table 3 and graphically in Figure 2. The insufficient material of *Ph. phoxinus* and *B. peloponnesius* has made it impossible for this equation to be calculated. If these are compared with the relative differences between the weighted masses and calculated on the bases of the obtained equations, we can see that four values exceed the value of 10 %, showing the existence of some irregularity in those length groups. Those are the length groups of 0,1–10 and 10,1–20 cm for *S. trutta* and 2,1–3 cm for juvenile *A. alburnus*. The rational behind these irregularities is sought in the participation of the *S. trutta* population samples from two different habitats, one limnetic and one lotic, for the length group 10,1–20, where for all the samples it was stated to be of lotic phenotype, or only one sample in the length group 0,1–10 cm to be of limnetic phenotype. This relationship for *S. trutta* can vary, which is important, not only for different habitats, but also for the same habitat, the lotic one, the upper and

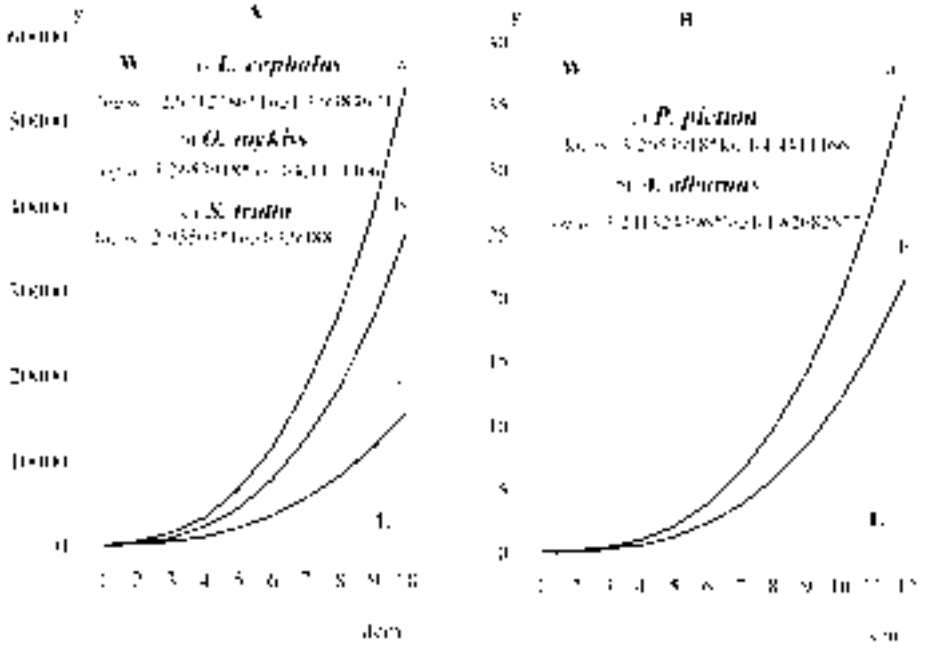

Figure 2. Graphical view of l–w relationship for: A) L. cephalus, O. mykiss *and* S. trutta*; B)* P. pictum *and* A. alburnus*–mutual values.*

Slika 2. Grafički prikaz suodnosa duljina tijela–masa za: A) L. cephalus, O. mykiss *i* S. trutta*; B)* P. pictum *i* A. alburnus*–skupne vrijednosti.*

lower part of the same brook, which is shown in the results of Georgiev (1978), for the Lipkovka river. While the equation is satisfactory for all the population of *A. alburnus,* the exclusion of juveniles could be the reason, because of participation of samples from different parts of the reservoir which are supposed to serve as microhabitats by different micro ecological conditions, deeper or shallower bays (Georgiev and Naumovski, 1982), one factor influencing the fish proportions, respectively l–w relationship.

Condition coefficient

The values for this character are shown in Table 4 for *S. trutta*, *O. mykiss*, *Ph. phoxinus*, *P. pictum* and *B. peloponnesius*, while separately for *A. alburnus* numerical in Table 5 and graphical in Figure 3A. Generally one thing can be concluded, despite the cruel climate conditions, the condition coefficient of the fish inhabiting the Mavrovo reservoir is good which indirectly implies that they have on disposition large nutritional possibilities, a study presented in the chapter below.

Table 4. Condition coefficient for L. cephalus, P. pictum, S. trutta, B. peloponnesius, O. mykiss *and* Ph. phoxinus.
Tablica 4. Koeficijenat uhranjenosti za L. cephalus, P. pictum, S. trutta, B. peloponnesius, O. mykiss *i* Ph. phoxinus.

(0)=n	months / mjesec										
	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
L. cephalus											
males / m	—	—	(3)	(28)	(4)	—	(3)	(19)	—	—	—
	—	—	**2.11**	**1.68**	**1.69**	—	**1.82**	**1.72**	—	—	—
females / ž	—	—	(1)	(3)	(15)	(7)	(8)	(22)	—	(1)	(2)
	—	—	**2.26**	**1.89**	**1.99**	**1.85**	**1.82**	**1.69**	—	2.20	1.83
juvenile / ml	—	—	—	(5)	(19)	(20)	(34)	(13)	(5)	—	—
	—	—	—	**1.51**	**1.89**	**1.77**	**1.72**	**1.64**	**1.69**	—	—
P. pictum											
males / m	—	—	(6)	(1)	(2)	(1)	(4)	(13)	(1)	—	(7)
	—	—	**2.52**	**2.09**	**2.21**	**2.21**	**2.06**	**1.96**	**1.83**	—	**2.18**
females / ž	—	—	(6)	(3)	(4)	(2)	(2)	(15)	(6)	—	(5)
	—	—	**2.58**	**2.37**	**2.20**	**1.96**	**1.94**	**2.27**	**1.93**	—	**2.24**
S. trutta											
Pole n	—	—	f (2)	—	f (1)	juv (1)	—	—	m (1)	m(2)	f(4)	m(1)	f(3)
	—	—	**1.64**	—	**1.37**	**1.92**	—	—	**1.65**	**1.62**	**1.61**	**1.50**	**1.56**

cont. Table 4 — nastavak Tablice 4

B. peloponnesius											
Pole n	—	—	f (3)	f(1)	f/II (1)	f(m)	—	f(1)	—	—	—
	—	—	**1.86**	**2.02**	**1.73**	**2.21**	—	**1.87**	—	—	—
O. mykiss (m+f+j)											
n	(2)	(1)	(8)	(6)	—	—	—	(4)	(1)	—	—
	1.44	**1.72**	**1.76**	**l.61**	—	—	—	**1.77**	**2.19**	—	—
Ph. phoxinus											
Pole n	—	—	—	f (2)	—	m (2)	f (2)	juv (3)	—	—	—
	—	—	—	**2.17**	—	**1.57**	**1.89**	**1.39**	—	—	—

Table 5. Condition coefficient for A. alburnus.
Tablica 5. Koeficijent uhranjenosti za A. alburnus.

(0)=n	months / mjesec											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
fem	(11)	—	—	—	(54)	(54)	(36)	(67)	(48)	(38)	(1)	(15)
aver	**1.22**	—	—	—	**1.44**	**1.49**	**1.52**	**1.43**	**l.31**	**1.46**	**1.56**	**1.37**
var	**1.1–l.3**	—	—	—	**1.1–2.0**	**1.0–l.8**	**1.2–2.0**	**0.8–2.0**	**1.1–l.5**	**1.2–l.6**	—	**l.l–l.8**
	—	—	—	—	—	—	—	—	—	(5)	—	—
	—	—	—	—	—	—	—	—	—	**1.15**	—	—
	—	—	—	—	—	—	—	—	—	**1.1–l.2**	—	—
males	(5)	—	—	—	(27)	(71)	(59)	(36)	(21)	(10)	—	—
aver	**1.33**	—	—	—	**1.44**	**1.37**	**1.50**	**1.41**	**1.31**	**1.25**	—	—
var	**1.2–l.5**	—	—	—	**1.2–l.9**	**1.1–l.6**	**1.1–2.3**	**0.9–2.1**	**1.1–l.6**	**1.2–l.5**	—	—
	—	—	—	—	(3)	(2)	—	—	—	—	—	—
aver	—	—	—	—	**1.27**	**0.84**	—	—	—	—	—	—
var	—	—	—	—	**1.2–l.3**	**0.8-0.9**	—	—	—	—	—	—
	—	—	—	—	(1)	—	—	—	—	—	—	—
	—	—	—	—	1.22	—	—	—	—	—	—	—
juv	—	—	—	—	(12)	(6)	(34)	(10)	(18)	(42)	—	—
	—	—	—	—	**1.16**	**1.16**	**1.36**	**1.31**	**1.23**	**1.29**	—	—
	—	—	—	—	**0.9–l.6**	**0.8–l.3**	**0.7–l.7**	**0.9–l.7**	**0.9–l.6**	**0.9–l.4**	—	—

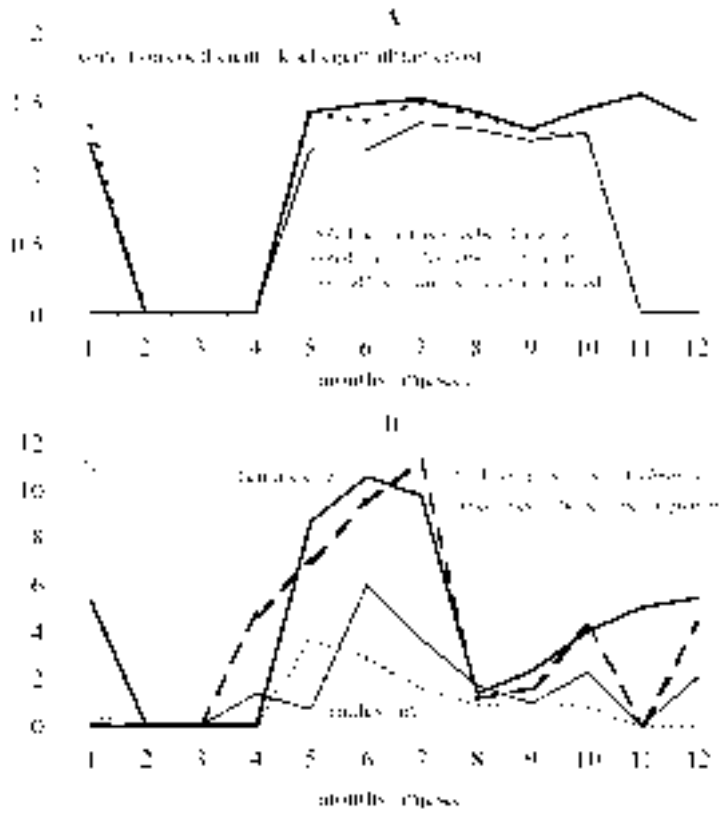

Figure 3. Graphical view of: A) condition coefficient for A. alburnus*; B) maturation coefficient for* A. alburnus *and* P. pictum.
Slika 3. Grafički prikaz: A) koeficijenta uhranjenosti za A. alburnus*; B) koeficijenta zrelosti za* A. alburnus *i* P. pictum.

Maturity coefficient

The results of these investigations are shown in Table 6 for *S. trutta*, *Ph. phoxinus*, *P. pictum* and *B. peloponnesius*, while separately for *A. alburnus* in Table 7. For *A. alburnus* and *P. pictum* those values are shown also in graphical form in Figure 3 B. Despite the discontinuity of samples in some months or lack of samples from the different sexes (*L. cephalus*), it is possible to follow the movement of the growing of the gonads of the different fish, without the introduced *O. mykiss*, due to the reasons explained in the chapter above. As far as *A. alburnus* is concerned, this article deserves a slightly larger comment. As many other cyprinid species, the Bleak is known as portion spawning fish which is also confirmed by the received results. The first portion of spawning takes place in the second half of June, and then in October; a

large variation of the maximal and minimal values for this feature was stated in the same month for the samples which fall in the same group of maturation, especially for the females, considered from macroscopic aspect. While the larger (older) fish are with advanced ovarian, some of them are »late« with their readiness to spawn and would eject different amounts from the ovarian in the first portion, about 5/4 of the ovarian content, and some of them hardly reach 1/3. This is reflected further on when the fecundity was considered by further differences (Table 8).

Table 6. Data on the coefficient of maturity for P. pictum, L. cephalus, S. trutta, B. peloponnesius *and* Ph. phoxinus.
Tablica 6. Podaci o koeficijentu zrelosti za P. pictum, L. cephalus, S. trutta, B. peloponnesius *i* Ph. phoxinus.

(0)=n	months / mjesec										
	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
P. pictum											
males / m	—	—	(6)	(1)	(2)	(1)	(4)	(13)	(1)	—	(7)
	—	—	**1.35**	**0.69**	**5.94**	**3.62**	**1.69**	**0.97**	**2.22**	—	**1.99**
females / ž	—	—	(6)	(3)	(4)	(2)	(2)	(15)	(6)	—	(5)
	—	—	**4.62**	**6.94**	**9.46**	**11.20**	**1.12**	**1.57**	**4.16**	—	**4.26**
L. cephaluss											
males / m	—	—	(3)	(28)	(4)	—	(3)	(19)	—	—	—
	—	—	**5.44**	**10.96**	**5.31**	—	**0.51**	**1.56**	—	—	—
females / ž	—	—	(1)	(3)	(15)	(7)	(8)	(22)	—	(1)	(2)
	—	—	**0.47**	**0.13**	**0.18**	**0.15**	**0.25**	**0.55**	—	**0.53**	**0.26**
S. trutta											
Pole n	f (2)	—	—	—	f (1)	—	—	—	m (1)	f (2)	f(3) m(1)
	0.65	—	—	—	**0.18**	—	—	—	**0.05**	**2.02**	**3.91**
B. peloponnesius											
Pole n	—	—	f (3)	f(1)	f/II(1)	f(m)	—	f(1)	—	—	—
	—	—	**4.78**	**9.94**	**0.49**	**6.64**	—	**1.54**	—	—	—
Ph. phoxinus											
Pole n	—	—	—	f (2)	—	m (2)	f (2)	Juv (3)	—	—	—
	—	—	—	**20.44**	—	**5.77**	**24.66**	/	—	—	—

Table 7. Coefficient of maturity for A. alburnus.
Tablica 7. Koeficijent zrelosti za A. alburnus.

(0)=n	Months / mjesec											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
fem	(11)	—	—	—	(43)*	(54) all	(36) all	(67) all	(48)	(33)**	(1)	(15)
aver	**5.3**	—	—	—	**8.76**	**10.47**	**9.7**	**1.34**	**2.3**	**4.05**	**5.04**	**5.45**
var	**4.3–6.9**	—	—	—	**2.1–20**	**2.3–20.2**	**0.8–14**	**0.1–11**	**0.8–6.5**	**2.5–5.7**	—	**3.6–7.5**
	—	—	—	—	(3)***	—	(11)**	(26)**	—	(5) II+	—	—
	—	—	—	—	**20.4**	—	**1.27**	**0.99**	—	**1.08**	—	—
	—	—	—	—	**15–29**	—	**0.2–3.6**	**0.1–1.7**	—	**0.8–1.2**	—	—
	—	—	—	—	(3)**	—	(3)*	(1)***	—	—	—	—
	—	—	—	—	**0.52**	—	**1.34**	**10.8**	—	—	—	—
	—	—	—	—	**0.1–0.3**	—	**1.3–1.5**	—	—	—	—	—
	—	—	—	—	—	—	(2)***	(12)*	—	—	—	—
	—	—	—	—	—	—	**7.24**	**1.82**	—	—	—	—
	—	—	—	—	—	—	**2.6–12**	**1.4–2.3**	—	—	—	—
males	(5)	—	—	—	(27)*	(71)	(59)	(36)	(21)	(10)	—	—
aver	**0.48**	—	—	—	**3.73**	**2.91**	**1.61**	**0.91**	**0.96**	**0.83**	—	—
var	**0.2–0.8**	—	—	—	**0.5–17**	**1.2–4.8**	**0.1–4.8**	**0.1–3.0**	**0.4–3.4**	**0.2–2.2**	—	—
	—	—	—	—	(3)**	—	—	—	—	(1)*	—	—
aver	—	—	—	—	**0.11**	—	—	—	—	**12.58**	—	—
var	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	(1)***	—	—	—	—	—	—	—
	—	—	—	—	**0.48**	—	—	—	—	—	—	—

* phase of fecundity=III; ** phase of fecundity=II; *** phase of fecundity=V or V/II; II+preparing for first spawn next year
* faza zrelosti=III; ** faza zrelosti=II; *** faza zrelosti=V ili V/II; II+priprema za prvi mrijest sljedeće godine

Table 8. Fecundity of A. alburnus, P. pictum, B. peloponnesius *and* Ph. phoxinus *females.*
Tablica 8. Plodnost ženki A. alburnus, P. pictum, B. peloponnesius *i* Ph. phoxinus.

absolute fecundity	relative fecundity
A. alburnus (n=31)	
8.340	**331.025**
3.060–16.100	91.826–2.671.139

cont. Table 8 — nastavak Tablice 8

P. pictum (n=5)	
12.560	**631.833**
6.387–16.400	175.974–648.221
B. peloponnesius (n=3)	
8.764	**100.435**
6.195–11.678	75.923–128.048
Ph. phoxinus (n=2)	
5.283	**78.522**
3.255–7.312	50.866–105.978

Fecundity

The ecological study of the fish was done on 41 samples from four species. From *A. alburnus*, a sample of only 31 female specimens was convenient for this study, the reason for this being explained in the chapter above, as opposed to the samples that Petrovski and Sidorovski (1980), had on their disposition. In general, all the results that have been obtained are within the frames of fecundity data published for the populations in the larger area of the species investigated. Only one female has shown extremely high value for the relative fecundity of about 2.500.000 roe. The received result is a consequence of the case of the female that had all the roe eggs in both the ovaries mature for spawning in one portion. The absolute fecundity of *A. alburnus* in Mavrovo Reservoir corresponds to the values given in literature (Vuković and Ivanović, 1971), whereas the results on the absolute fecundity of *Ph. phoxinus* females in Mavrovo Reservoir, with only two samples, surpass by far the value given by Vuković and Ivanović (1971).

Nutrition

The nutrition of the fish in the Mavrovo Reservoir is shown in Table 9. The opulence with food for the fish originates from the submersed mountain pastures, which are periodically flooded and desiccated when the water level decrease, as it has been cited for 26 m. The large grassed plains, densely inhabited by terrestrial animals (insects, worms and snails), when flooded represent a reach feeding possibility for the fish, also when dry the rains bring grains and insects in the reservoir, so it is clear why we find so many different groups in the feeding compounds of the fish, inside benthal typical water groups are still habitats Odonata, Diptera, Coleoptera, Trichoptera (expected Ephemeroptera and Plecoptera lack because they dominate in the fluent habitats) plankton lower cryfishes *Daphnia* and *Diaptomus*, Rotatoria from animals and filament algae also perifyton Diatoms, and outside insects Pentatomidae, Formicidae, Vespidae etc.

Table 9. Nutrition of the fishes from the Mavrovo Reservoir.
Tablica 9. Hranidba riba iz Mavrovske akumulacije.

spring / proljeće				summer / ljeto				autumn / jesen				winter / zima			
Σ	Full % puna	Empty % prazna		Σ	Full % puna	Empty % prazna		Σ	Full % puna	Empty % prazna		Σ	Full % puna	Empty % prazna	
S. trutta															
2	(100)	—		2	(100)	—		1	—	(100)		11	(10)	(10)	(90)
Odonata (100)				Coleoptera i (100)								Chironomidae l(100)			
Diptera l. (100)				Trichoptera (100)											
				B. peloponnesius (100)											
O. mykiss															
15	(100)	—		—	—	—		19	(100)	—		2	(100)	—	
B. peloponnesius (100)								*A. alburnus* (100)				Coleoptera (50)			
								Insecta (20)				*A. alburnus* (100)			
												Pentatomidae (50)			
												Vespidae (50)			
												Formicidae (50)			
												Lepidoptera l (50)			
A. alburnus															
236	(100)	—		226	(97)	(3)		184	(98)	(2)		32	(100)	—	
Aquatic Insects n (100)				Chironomidae, i, l, (100)				Crustacea (10)				*Daphnia sp* (100)			
Daphnia sp (100)				Crustacea (10)				Insecta (50)							
				Cormophyta (10)				*Daphnia sp* (100)							
				Coleoptera i. (20)				*Oscillatoria* (30)							
				Diaptomus (10)				Cormophyta (10)							
				Oscillatoria (30)											
				Copepoda (5)											
				Diatomeae (30)											
				Daphnia sp (100)											
L. cephalus															
62	(90)	6(10)		90	(90)	(10)		62	(95)	(5)		11	(100)	—	
Diptera (100)				*Oscillatoria sp.* (60)				*Oscillatoria sp.* (70)				Detritus (100)			

cont. Table 9 — nastavak Tablice 9

Trichoptera (30)	Diatomeae (60)	Diatomeae (50)	
Coleoptera aquatic (20)	Rotatoria (5)	Phanerogamae (10)	
Algues (50)	Chironomidae l. (30)		
Oligochaeta (10)	Coleoptera i. (7)		
Coleoptera Terrestrial (20)	*Daphnia sp.* (1)		
Cormophyta (20)			
P. pictum			
12 (100) —	1 (100) —	6 (20) (80)	11 (100) –
Chironomidae +Detritus (100)	Cladocera (*Chydorus sp.)*	Chironomidae (100)	Chironomidae (100)
Aquatic Insecta l. (100)	Copepoda (*Cantocampus sp.)*		
Diptera l. (100)	Chironomidae		
	Oscillatoria sp.		
B. peloponnesius			
3 3 (100) —	4 (75) (25)	1 (100) —	— — —
Aquatic Insecta l. i. (100)	Aquatic Insecta l. i. (100)		
Terrestrial Insecta i. (100)			
Ph. phoxinus			
2 (100) —	4 (50) (50)	3 (100) —	— — –
Oscillatoria sp (100)	Chironomidae (100)	Diatomeae (100)	

i=imago; l=larva; n=nymph

From the nutrition it is possible to see that the indigenous fish *S. trutta* has kept the nutrition behaviour as Popovska — Stanković and Georgiev (1973), have stated; the other competitor, the introduced *O. mykiss* has a larger spectrum of taken food, *B. peloponnesius* is fish feeding itself on zoophagous benthos as the previous two nektonic and pelagic *S. trutta* and O. *mykiss*, while in the *Ph. phoxinus* and *P. pictum* endemic one, where the spectrum of food is also narrow, the fauna compounds prevailed over the floristic; the same can to be stated for both the littoral and benthos shoreline *L. cephalus* and the widespread (littoral, benthal and pelagic) *A. alburnus*; both of them have consumed a far larger spectrum of food. Judging by the food composition three groups of competitors can be discovered which are: *S. trutta*/*O. mykiss*; *B. peloponnesius*/*P. pictum*; *A. alburnus*/*L. cephalus;* however

it is impossible to draw any conclusions about the feeding competition coarseness existing among those three groups from those results.

CONCLUSIONS

1. Mavrovo Reservoir has begun to exist as monotypic fish settlement consisting of indigenous *S. trutta*, which originates from the fluent population and in the past, it has been well examined from the point of view of its ecology.
2. Later on, the anthropogenic factor has influenced once again the primarily fluent population of *S. trutta*, adding five indigenous species, already existing in the same flow: *A. alburnus*, *L. cephalus*, *B. peloponnesius*, *Ph. phoxinus*, endemic one *P. pictum* and one foreign *O. mykiss*.
3. The smallest fish regarding the maximal dimensions *Ph. phoxinus* has disappeared during the project duration.
4. The other fish introduced, regardless whether indigenous or alochtone for the flow, enjoy good ecologic conditions in the Mavrovo Reservoir, despite the high elevation and cruel climate during the winter.

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Sažetak

IZMJENA I SUSTAV RIBA U MAVROVSKOJ AKUMULACIJI (REPUBLIKA MAKEDONIJA)

S. Georgiev

U radu su iznesene neke ekološke odlike riba koje čine riblju populaciju Mavrovske akumulacije, u kojoj obitava jedna autohtona i šest unesenih vrsta riba: *Salmo trutta* (Linnaeus, 1758), *Oncorhynchus mykiss* (Walbaum, 1796), *Leuciscus cephalus* (Linnaeus, 1758), *Pachychilon pictum* (Heckel & Kner, 1858), *Phoxinus phoxinus* (Linnaeus, 1758), *Barbus peloponnesius* Valenciennes, 1844 i *Alburnus alburnus* (Linnaeus, 1758). Tijekom istraživanja vrsta *Ph. phoxinus* je nestala. Najgušću populaciju ima *A. alburnus*, pelagična, ali i litoralna vrsta u isto vrijeme; na drugom je mjestu *P. pictum*, endemična vrsta

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za slijev, bentosna, kao što je i *B. peloponnesius*. *L. cephalus,* dok je mlada, litoralna je i nektonska riba, a kad odraste, postaje bentosna. Populacija autohtone *S. trutta* vrlo je prorijeđena. Podaci o koeficijentu uhranjenosti, suodnosu duljina tijela–masa, gonosomatskom suodnosu i prehrani pokazuju da sve vrste, osim nestale *Ph. phoxinus,* nalaze povoljne ekološke uvjete, unatoč nadmorskoj visini akumulacije od oko 1233 m iznad razine mora te oštrim klimatskim uvjetima tijekom zimskog razdoblja.

Ključne riječi: *Mavrovska akumulacija, Makedonija, ekologija riba,* Salmo trutta*, limnetička nastamba, Nacionalni park, poribljavanje*

Lektura Elisaveta Koteska

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