

Analysis of the Brown Trout's *Salmo trutta* (*Fario*) Rate of Growth before and after Forming the Piva Reservoir

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Abstract: In this work it has been analysed the brown trout's rate of growth *Salmo trutta* (*fario*), before and after forming the Piva reservoir. It has been studied and compared growth of the population from the Piva river, shortly before forming the Piva reservoir, than growth of the population from the Piva Lake two years as well as fifteen years after forming the Piva reservoir. The considerable differences in growth have been established among the population in these three different periods.

Key words: Brown trout, rate of growth, Piva river, Piva reservoir - before and after forming.

Introduction

The Piva Lake is setteled in the north - west part of Montenegro. It presents a permanent, deep and rocky water accumulation with steep valley sides which are only partly covered by the forest.

During 1975, the Piva reservoir was formed by sinking the canyons of the Piva river, the Komarnica river, as some parts of their tributaries.

According to its depth, which is over 60 meters, the Lake is considered to be among the deep accumulations, while according to its form it's considered to be among, so called, the river accumulations or the long ones (Petkovic & Petkovic, 1977). The most useful depth of accumulation is about 187.5 meters while the average depths are about 70 meters. The length of the accumu-

lation is 40 kilometers, and the average width is about 300 meters¹.

The peak elevation of the accumulation is 650.0 meters height above sea level and it provides area of 1125 hectares (112.5 square kilometers) beneath the water, that is about 790 cubic meters of the useful water volume, in other words, the volume of 900 cubic hectometers. The average area of the volume of 560 cubic hectometers (Petkovic & Petkovic, 1977).

In keeping with measurements of progress and protection of the running waters, and especially the water accumulations, more and more attention has been paid to the problems of the water accumulations, especially in recent time.

Depend on the environmental conditions and biology of every single species in the water accumulations, the autochthonous species stay at the settlement, but the different variations in adaptations are appeared, what cause increasing or reducing of every single populations of the concrete species. For example, before sinking, twelve species from the four fish families are: *Salmonidae*, *Cyprinidae*, *Thymalilidae* and *Cottidae*. After sinking, only the three species from three families live in accumulation. From the *Salmonidae* family: *Salmo trutta m. fario*, from the *Cyprinidae*: *Phoxinus phoxinus* and from *Thymallidae* family: *Thymallus thymallus*.

In this work it has been analysed the brown trout's, *Salmo trutta m. fario*, rate of growth before and after forming the Piva reservoir.

Material and Methods of Work

Ichthyology field investigations were in 1974, before sinking, and carried out by the apparatus for electric fishing "Honda" (2.5 kilowats). The investigations done in 1977 and in 1990, that is after sinking, were carried out by the stagnant fishnets, that is "skobalj fishnets", which diameter of a mesh is 36 milimeters, as well as by "poponica fishnets" with mesh diameter from 12 to 56 milimeters.

The fish age was determined by one of the oldest and the most applicable methods which determine the age on the basis of growing zones on the scales (Senk, 1954). The scales were taken under the dorsal fin.

The rate of growth was determined on the basis of the calculated arithmetic means ($\bar{x}$), the absolute and relative annual growth increase.

The total number of 435 specimens were worked out at the laboratory of the Institute of Biology.

Results and Discussion

The length and the weight growth of the brown trout, *Salmo trutta (farior)*, has been analysed during three periods:

- from the Piva river and its tributaries on October 1974, the period before forming the Piva reservoir;
- from the Piva reservoir on October 1977, two years after sinking;
- from the Piva reservoir in November 1990, fifteen years after sinking;

¹ Report about the Piva river, Institute of Biology in Titograd (1981).

Growth has been studied on the basis of the arithmetic mean values of the measured weight and lengths of the bodies according to age classes, and the absolute and relative growth (%).

The samples come from the same period (shortly before spawn period) and make comparisons possible. Because the growth is practically completed, the age groups present a whole year of living.

The brown trout population from the Piva river consists of six age groups. The most numerous age group is 0⁺ with 84 individuals (39.1 %). The less numerous age group is 5⁺ with 3 individuals (1.4 %). Then 4⁺ with 9 individuals (4.2 %), 3⁺ with 50 individuals (23.2 %), 2⁺ with 49 individuals (22.8 %).

According to the obtained results it can be concluded that the brown trout, *Salmo trutta (fario)* attains the length of 50.0 to 98.0 millimeters ($\bar{x} = 77.4 \pm 1.14$) and weight of 1.0 to 8.8 grams ($\bar{x} = 5.4 \pm 0.21$) during its first year of living in the Piva river. During two years of living (1⁺) the brown trout attains from 92.0 to 137.0 millimeters in the length ($\bar{x} = 112.3 \pm 1.56$) and from 8.0 to 25.6 grams in the weight ($\bar{x} = 15.8 \pm 0.60$) and during three years of living (2⁺) from 120.0 to 170.0 millimeters in the length ($\bar{x} = 145.2 \pm 2.41$) and from 15.5 to 64.6 grams in the weight ($\bar{x} = 36.7 \pm 2.24$).

The stronger variations in the weight and in the length in these first age group could be, besides other factors, the results of spawn during different periods of year. It was found that the brown trout was spawning from November until February and the age difference among fingerlings is more than two months.

In this period of living (three years) the brown trout has an intensive growth, especially in gaining weight, which is characteristics of the juvenile organisms.

Greater relative growth values of the weight show that the weight growth is rapid. This kind growth is characteristics of some salmonids from the Ohrid Lake (Stefanovic, 1948). In the second period of living from 3⁺ to 5⁺ (sex ripe specimens) the relative growth is less intensive, and it is also characteristics of some other fish species (Jankovic, 1961, Soric, 1982). It has been also established the growth of the brown trout in the rivers of Yugoslavia as the growth of the brown trout, *Salmo trutta (fario)*, in the Piva river (Ocvirk, 1984, Drecun et al., 1985).

In the second studied period (two years after sinking) the brown trout population consists of four age groups (3⁺ - 6⁺), 5⁺ with 55 individuals (53.4 %), still 4⁺ with 25 individuals (24.3 %), 3⁺ with 13 individuals (12.6 %) and 6⁺ with 10 ones (9.7 %). A small number of the specimens in the youngest age group is caused by selection of the fishnets. Regarding the age group 3⁺ which is in fact the age group 0⁺ from the Piva river, it must be expected that the number of age group 3⁺ is larger. If we know that larger number of smaller specimens from the age group 3⁺ aren't fished by the fishnet, it can be concluded that the mean value of weight and length is even smaller. The length of 210.0 to 285.0 millimeters ($\bar{x} = 262.3 \pm 17.27$) and the weight of 80.0 to 280.0 grams ($\bar{x} = 190.8 \pm 7.01$) were established on the basis of the sample taken for this group. The relative growth between 3⁺ and 4⁺ is the smallest, 7.47 and 49.52 and it is less for some 30 % than growth in this period in relation to the other two periods. As it has been emphased before the relative growth of the different fish species are falling

with age, what favour assertion that established mean values of weight and length, in other words, a small number of specimens, in the age group 3⁺ and 4⁺, is greater. The length of 250.0 to 364.0 milimeters ($\bar{x} = 298.8 \pm 9.11$) and the weight of 156.0 to 325.0 grams ($\bar{x} = 246.6 \pm 4.21$) were determined for the age group 4⁺, the length of 287.0 to 375.0 milimeters ($\bar{x} = 322.4 \pm 5.98$) and the weight of 225.0 to 450.0 grams ($\bar{x} = 342.2 \pm 2.33$) for the age group 5⁺, and the length of 334.0 to 383.0 milimeters ($\bar{x} = 364.4 \pm 16.67$), and weight of 380.0 to 540.0 grams ($\bar{x} = 469.0 \pm 4.76$) for the age group 6⁺.

Tab. 1.a - Values of the relative growth of length from the three diferent periods

Period	Age groups					
	0 ⁺	1 ⁺	2 ⁺	3 ⁺	4 ⁺	5 ⁺ 6 ⁺
1974		4.51	29.3	24.6	21.8	24.9
1977					7.7	7.8 13.1
1990				16.2	13.6	15.8 10.5

Tab. 1.b - Values of the relative growth of weight from the three diferent periods

Period	Age groups					
	0 ⁺	1 ⁺	2 ⁺	3 ⁺	4 ⁺	5 ⁺ 6 ⁺
1974		192.6	123.3	89.9	93.4	48.4
1977					29.5	38.8 37.1
1990				47.5	42.3	41.5 53.7

Comparing growth of the brown trout population, *Salmo trutta (fario)*, from the Piva river with growth of the population, which one part of its living spent in the river, and other one in the Lake, the rapid growth of the brown trout population was noticed in the second period. During four years of living it reached the length and weight which the river population would reach in six years.

Next year, after forming the reservoir, the accumulation was stocked with fingerling of the brown trout *Salmo trutta (fario)*. Stocking with fingerling is permanently carried out year. Fished individuals in 1990 come from the stocked fingerling.

In this period it has been found out five age groups (2⁺ - 6⁺). It was noted 26 individuals (24.5 %) in the age group 2⁺, 39 individuals (36.8 %) in the age group 3⁺, 24 individuals (22.6 %) in the age group 4⁺, 14 individuals (13.2 %) in the age group 5⁺ and three ones (2.8 %) in the age group 6⁺. If we compared this period with the previous one (the second period) we'll find out that this population has even more rapid growth. So, for example, during three years, the age group 2⁺ reaches the values of 267.0 to 335.0 milimeters ($\bar{x} = 302.2 \pm 7.18$) and 200.00 to 430.0 grams ($\bar{x} = 302.3 \pm 17.05$) that the population from the previous period reach in more than five years. During four years (3⁺) reaches the length of 295.0 to 424.0 milimeters ($\bar{x} = 351.3 \pm 5.0$) and the weight of 280.0 to 660.0 grams ($\bar{x} = 445.8 \pm 14.50$) that the population from the second period reaches in less than seven years. Among the age of 4⁺ (five years), reached

values are from 410.0 to 800.0 grams ($\bar{x} = 634.5 \pm 25.0$), during six years (5⁺) reaches from 400.0 to 495.0 millimeters ($\bar{x} = 462.1 \pm 9.41$) and from 715.0 to 1020.0 grams ($\bar{x} = 897.7 \pm 28.4$), during seven years (6⁺) reaches from 485.0 to 535.0 millimeters ($\bar{x} = 510.7 \pm 14.45$) and from 1020.0 to 1560.0 grams ($\bar{x} = 1380.0 \pm 180.0$).

Besides presented valued, the greater relative growth of weight and length has been established in relation to the second period. The rapid growth of this population has been influenced by many factors. Stocking with fishes is done every year. Fingerling used for stocking the Lake were raised in the fish ponds until the age of six months and after that they were moved into Lake. During that time the fingerling reached weight and length greater than weight and length. That the population from the Piva reservoir would reach in one year. Besides considerable differences in the first year growth in relation to the second period, the third period has better conditions for nutrition. After forming the reservoir, the production of phytoplankton and other organisms, for example, the invertebrate, was increased by stabilization of the Lake's conditions (Marko *et al.*, 1968). Beside the rapid growth of the lower organisms, the species *Phoxinus phoxinus* that significantly participates in the nutrition, has been multiplied in the Piva reservoir. Analysing the digestive tract of the brown trout population, in some 80 % of the observing cases, it was discovered this cyprinid. During summer period, beside this cyprinid, the fingerling whom the Lake has been stocked that year, were found in the brown trout's stomach. The established growth values of the brown trout from the third period are approximately equal to the growth of *Salmo farioides* (Karaman, 1937) from the Mavrovo Lake (Sidorovski, 1971). The values are less in relation to the growth of *Salmo trutta labrax* Palas, *phorma lacustris* (L.) from the Plav Lake (a natural one) (Jankovic, 1964). It should be especially emphasized that the values in the age of 2⁺, of the brown trout population from the third period, are identical to the population from the Plav Lake. The trout from the Plav Lake can even grow up to twelve kilograms (Drecun, 1956), and up to ten kilograms in some natural Lakes (Taler, 1952), and up to 25 kilograms in the reservoir (Pazur, 1969). According to this author the brown trout from the Lokvark reservoir reaches the length of 480.0 millimeters in seven years what corresponds to the growth of the population from the third period.

According to the presented data about the growth of the brown trout *Salmo trutta (farior)*, can be assumed that the brown trouts will reach greater values than the established ones, even in the Piva reservoir.

Conclusions

According to the investigations about the growth of the brown trout *Salmo trutta (farior)* during three different periods, before and after forming the Piva reservoir, a few conclusions can be drawn.

The first, the same age groups have been studied, what made it possible to compare rates of growth.

The second, growth of the brown trout *Salmo trutta (farior)* in the Piva river is characteristics to the growth of brown trout in smaller rivers and is more intensive during the first years of living (untill the sexual ripe).

The third, the rate of growth among the age groups in the second research period is approximately equal.

The fourth, the age groups of the third period are also charcteristized by approximately equal rate growth.

The fifth, the absolute growth in the second research period, are more intensive than the growth of the population from the Piva river, but less intensive than the growth of the population from the third period.

The sixth, the relative growth among the age groups in the second period is lesss than corresponding one from the first and the third period.

The seventh, like the growth of the brown trout *Salmo trutta (farior)* in the third period, the growth in some other artificial Lakes has been also established.

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ANALIZA TEMPA RASTA POTOČNE PASTRMKE *SALMO TRUTTA (FARIO)* PRIJE I POSLIJE FORMIRANJA AKUMULACIONOG JEZERA PIVA

-originalni naučni rad-

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Rezime

Prije formiranja akumulacionog jezera Piva, analizom ihtiofaune, evidentirano je dvanaest vrsta iz četiri familije: *Salmonidae*, *Cyprinidae*, *Thymalidae* i *Cottidae*. Nakon formiranja akumulacije, evidentirane su samo tri vrste iz tri familije koje žive u akumulaciji. Iz familije *Salmonidae*: *Salmo trutta m. fario*, iz familije *Cyprinidae*: *Phoxinus phoxinus* i iz familije *Thymallidae*: *Thymallus thymallus*.

U ovom radu analiziran je i poredjen tempo rasta potočne pastrmke *Salmo trutta (farior)* iz rijeke Pive i njenih pritoka, prije formiranja akumulacionog jezera Piva, zatim tempo rasta nakon dvije odnosno petnaest godina nakon formiranja akumulacije.

U prvom ispitivanom periodu (prije formiranja akumulacionog jezera) u uzrasnoj strukturi populacije potočne pastrmke evidentirano je šest starosnih grupa. Najbrojnija je 0⁺ uzrasna klasa sa 39%. Tempo rasta potočne pastrmke u rijeci Pivi, ima intenzivan rast tokom prve godine života. Dominacija mlađjih uzrasnih grupa ukazuje na brzi porast populacije. U drugom ispitivanom periodu (dvije godine nakon formiranja akumulacije) utvrđeno je da je populacija sastavljena iz četiri uzrasne grupe (3⁺ - 6⁺). Manji broj uzoraka u mlađjim uzrasnim klasama pretpostavlja se da je uzrokovan selekcijom mreža.

U trećem ispitivanom periodu (petnaest godina nakon formiranja akumulacije), utvrđeno je pet uzrasnih klasa (2⁺ - 6⁺). Ako se uporedi navedeni period sa prethodnim (drugim periodom) može se zaključiti da populacija iz trećeg ispitivanog perioda ima znatno intenzivniji rast.

Ako se uporedi tempo rasta populacije potočne pastrmke *Salmo trutta (farior)* iz rijeke Pive, sa tempom rasta populacije potočne pastrmke koja je jedan dio života provela u rijeci a drugi u jezeru, intenzivniji tempo rasta potočne pastrmke utvrđjen je u drugom periodu. Tokom četiri godine života ova populacija potočne pastrmke postiže dužinu i masu, koju populacija iz rijeke Pive dostiže za šest godina življenja.