The Impact of Environmental Conditions on Growth and Development of *Salmo Letnica* Smolt

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Abstract
Salmo letnica, is one of the most important species of the Lake Ohrid. It is a freshwater fish that lives in cold and rich in oxygen water. Based on its biological and economic importance since 1935 in Macedonia and in Albania since 1995, there have been applied techniques of artificial fertilization and cultivation of *S. letnica*. Despite adjusting the physical parameters of the water, these fishes show stress in artificial growth environment, which is associated with reduction of their biomass and in many cases even death. There are also private economies to deal with the growth and development of *S. letnica* for marketing effect. Use of different food regimes has influenced in different amounts of biomass in the same age fish. Through this study we want to show the importance of environmental conditions and nutrition in the growth rates which are reflected in the productivity and the healthy life of this fish.

Key words: biomass, nutrition regime, physical water parameters, *Salmo letnica*, stress

1. Introduction

Lake Ohrid is localized in the massive karst Sara-Pindus [1]. The lake fills the largest space of the Ohrid field (40,54'-41,10'N and 20,38'-20,49'E) southeast of the Republic of Macedonia and separating the southeast shore of the Republic of Albania [2].
Lake Ohrid is one of the lakes that have been part of continuous research since the end of the 19th century. A large number of these studies are part of the big number of relics and the types of endemics that populate the lake [1]. Lake Ohrid is a place for numerous bodies of freshwater Tertiary Period, close relatives who can be found just as fossil remains [3]. This is why the lake is sometimes called a "museum of living fossils" [4]. Among them is included the famous Ohrid trout (*Salmo letnica*). Lake Ohrid Trout is part of the *Clupeiformes* order, *Salmonidae* family, genus *Salmo* [5, 6]. *Salmoniformes* are recognized as the top predator of the pyramid chain in cold water lakes in the north hemisphere. The most important ecological factor that limits the life of the genus *Salmo*, is the temperature of the water (4-18˚C), which also indicates that the rhythm of life cycle for the members of *Salmo* genus is lower than in other freshwater fishes in Europe [7]. For example females of *Salmo* genus, mature at age +7 years [8]. This also shows that the evolution of trout has been conducted slower that other fish species. In 1935 on the Macedonian side, a program was established to increase artificially fertilization and opening of native trout in order to support the natural recruitment of *S. letnica* [9]. Setting up a Hydrobiological station established at the same time fulfills the artificial cultivation of *S. letnica* and they have worked as an integrated whole since

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that time. Since the year 1995, taking into account that larval survival in the lake resulted in a lower rate, and fishing stocks of *S. letnica* from year to year got lore as well, it was decided to experiment growth of larvae in the stage of fingerling in conditions of Lin economy. From the year 2003 onwards as a result of the reconstruction of the economy and the implementation of new technologies, the amount of fingerlings from what produced this economy has been growing ranging from 700 000 to 1 million fingerlings a year. Lake Ohrid is rein habited each year, as well, by the Macedonian side with about 1 million 400 000 fingerlings. So, the amount of *S. letnica* in the lake gets higher from their artificial reproduction. Private economies deal with the cultivation of *S. letnica* in both lake sides. The use of concentrated feed and increase in not deep basins results in the observation of pigmentation more pronounced in these fish. Application of different food regimes, environmental conditions, and physical parameters of water has shown different rates of growth in *S. letnica* smolt. Displaying stress is another factor that influences the performance of the cultivation of these fish.

2. Materials and methods

For this study, fish were used from the Trout cultivation economy in Lin, Pogradec. They were grown there after artificial insemination, piled randomly. The fish in the study were aged over 1 year old and measurements were conducted during three months: June, July and August 2014. They were divided into two areas with different water parameters and with a different food regimen. In the tank located in the internal environment of the implant with the size: 1 m width, 1.5 m length and 1 m depth, the temperature varies from 8.9-10°C. In the tank located outside the economy, with the size 3 m length, 2 m width and 1.8 m depth, water temperature varies from 10.1-13°C. The water temperature was measured every day with PHYWE sensor 2009. The same thing was done with the measurement of pH values, dissolved oxygen and nitrates and nitrites. In the tank inside the economy, the measured values of dissolved oxygen ranging from 7.4-8.2 mg/l, whereas in the tank outside, they ranging from 7.5 mg/l to 10.4 mg/l. The pH values were the same as for the environment inside and outside, with fluctuations of 7-7.4. The same thing can be said of nitrites and nitrates. The presence of these ions in both environments is the same, namely the amount of nitrite ions ranging from 0.001mg/l-0.016 mg/l, while nitrate ions from 0.01 mg/l–0.12 mg/l. The length–weight relationship, as an indication of their growth, was determined by the equation $W=aL^b$, where "W" is the body weight of fish (g), "L" is the total length (cm), "a" is the scaling coefficient (intercept) and "b" is the regression coefficient (slope). Parameters "a" and "b" in length-weight relationship were evaluated based on the logarithm in base 10, log (W)=log (a)+b log (L). Generally, in fish "b" ranges from 2-4; when "b" value corresponds to 3 or very close to 3, it is said that fish exhibited isometric growth; when "b" has a value less than 3 it is said that fish exhibited negative allometric growth; when "b" is greater than 3, it is said that fish exhibited positive allometric growth [10]. The determination coefficient (R^2) was used as a quality indicator of linear regression [11]. Statistical analyzes were conducted by using the linear regression in Microsoft Office Excel 2007. To realize measurement of weight and fish total length initially they were anesthetized with clove oil based on Prince and Powell (2000) [12].

Their total length ranging from 12 cm-23.4 cm while the weight of 15.62 g-99.1 g Food intake used for both experimental environments was different. In tank inside the economy, fish were fed every three hours while in the tank outside the economy fish were fed every two hours. In both cases commercial pellet was used, but with different percentages of the constituent elements. In the tank inside the fishes were fed with pellet comprising 55% protein and 13% lipids, while for the tank outside the fish's food contained 66% protein and 15% lipids. The performance of fish was attended every day from the study team and the plant specialists of Trout cultivation economy. Over the days and with their growth was noticed unusual movements put to keep the fish tanks in the inside environment. Farmed fish have a higher risk of mortality and poor welfare, showing that the current methods of aquaculture do not meet the welfare needs of the whole fish [13].

Stress display of fish was associated with their skin damage as a result of friction in the tank walls. Given that the fish grown in the outside environment, such behavior were rare, we conclude that the outside environment was more

favorable conditions for the life of *S. letnica* smolt.

3. Results and discussion

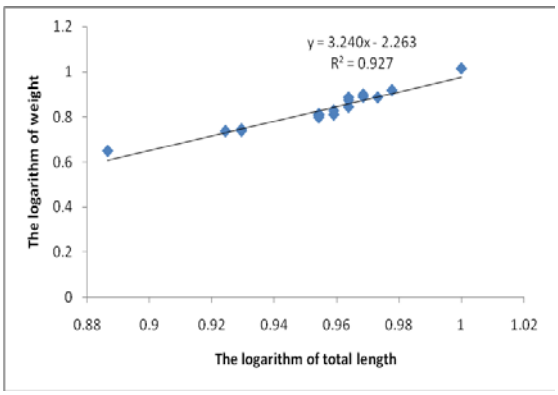
Results obtained for the length–weight relationship and the fish growth exhibition are presented in Table 1. The measurements are realized for both tank inside (I) and outside (O) *S. letnica* growth and cultivation economy in Lin, Pogradec. The temperature values presented the average of every day measurements. From the linear regression of length- weight relationship is calculated the regression coefficient "b" that is directed linked with the growth type of samples (-A negative allometric growth, +A positive allometric growth, I isometric growth) (Table 1).

Table 1. Regression coefficients of length-weight relationships of *Salmo letnica* fed different food regime at two different environments (inside and outside)

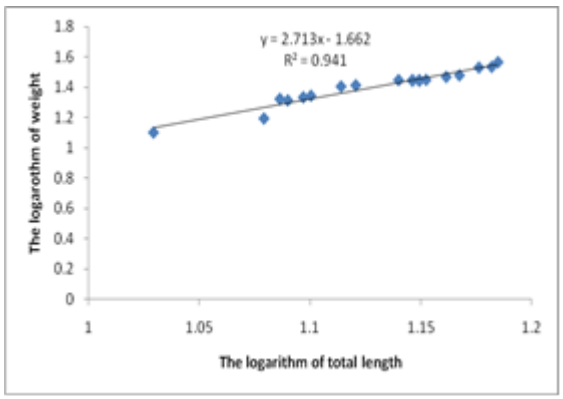
Mounth	Food intake	T (°C)	Regression coefficient (b)	Type of growth
June (I)	Every 3 hours per day	8.9	2.71	-A
June (O)	Every 2 hours per day	10.1	3.24	+A
July (I)	Every 3 hours per day	10	1.2	-A
July(O)	Every 2 hours per day	12.3	2.96	I
August (I)	Every 3 hours per day	9.7	1.17	-A
August (O)	Every 2 hours per day	13	3.05	+A

The temperature shows the average temperature of the month; the regression coefficient (b) is estimated from the linear regression of the length-weight relationship; -A for negative allometric growth, +A for positive allometric growth and I for isometric growth

In the present study, the length-weight data were considered to establish the growth form of *S. letnica* at different artificial environment and different diet regime. If fishes grow isometrically, they retain body shape and the *b*-value must be equal to 3.0 [14, 15]. Under natural conditions, most fish do not show the cube law, because they change their body shape as they grow or increase in size and become heavier in one season and lighter in another. The relationship between length and weight of fish may depart from the ideal value (3.0), which may be due to certain environmental conditions or the condition of the fish themselves [16]. Therefore, the *b*-value for each fish species could be significantly greater or less than the ideal value, indicating that growth pattern is allometric [17]. Thus, if the *b*-value is equal to 3.0, growth is isometric, but if the *b*-value is less than 3.0, fish become more slender as they increase in length; therefore, growth will be negatively allometric, which might be because habitat conditions are not suitable for growth. On the other hand, if the *b*-value is greater than 3.0, fish become heavier and show a positive allometric growth for their specific lengths, which may be due to optimum conditions [17]. Temperature and diet regime interacted to determine the growth in cultured *S. letnica*. In addition, a higher temperature could increase the metabolic rates of fish [19], thereby accelerating their digestion process [20] and inducing better (isometric and positive allometric) growth. In figure 1 there is the graphic presentation of logarithmic values for length-weight relationship in both tanks; inside and outside the economy. Except the temperature values, in these different environments is used different diet regime. In the tank inside fishes were fed every three hours with pellet containing 55% protein and 13% lipids, whereas in the tank outside they were fed every two hours with pellet containing 66% protein and 15% lipids. In graph a) and graph b) there is the linear regression for June measurements, respectively in graph a) for fishes in the tank outside and in graph b) for fishes in the tank inside the growth and cultivation *S. letnica* economy in Lin. The average water temperature in tank inside during June was 8.9°C, while in tank outside it was 10.1°C. The determination coefficient, R^2, in graph a) is 97% and in graph b) 94%, with a high significance for very low P value ($P<0.001$). The regression coefficient in graph a) shows a positive allometric growth with b=3.24. Fishes in tank placed inside the economy, have shown a negative allometric growth with b=2.71.



a)



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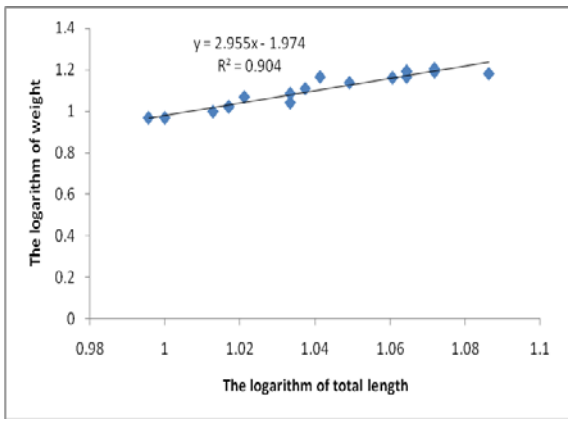

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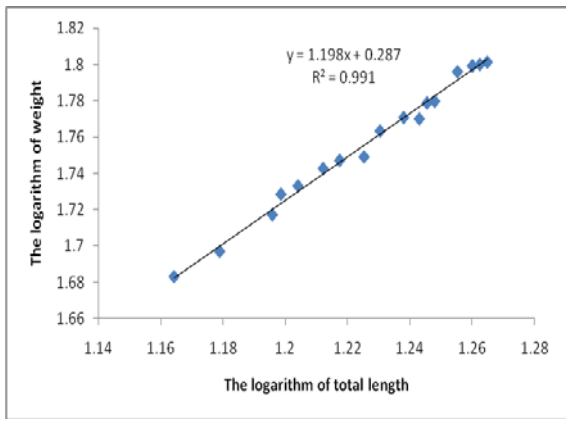

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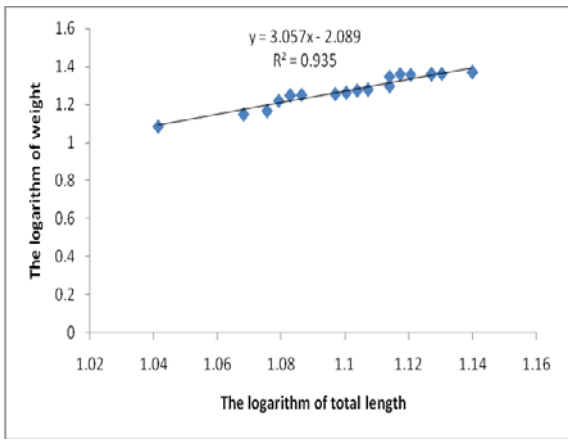

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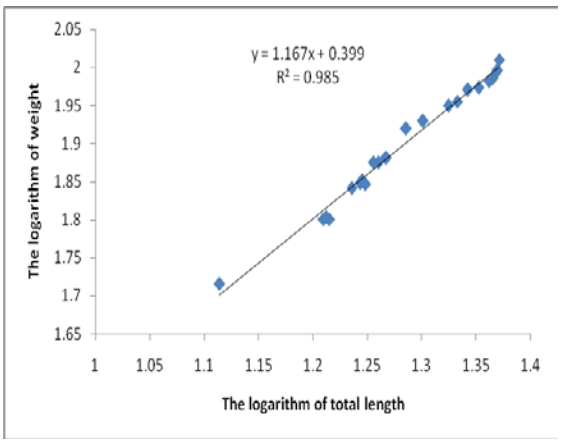

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Figure 1. The graphic presentation of linear regression for logarithmic length- weight relationship for three months: a) the graph for June measurements in the tank outside, b) the graph for June measurements in the tank inside, c) the graph for July measurements in the tank outside, d) the graph for July measurements in the tank inside, e) the graph for August measurements in the tank outside, f) the graph for August measurements in the tank inside.

The July growth analyses are presented in graph c), for the tank outside the economy and graph d), for the tank inside the economy. The average water temperature in tank inside was 10°C, while in tank outside it was 12.3°C. In graph c) fishes exhibited isometric growth with b=2.96 and in graph d) they exhibited negative allometric growth with b= 1.2. The determination coefficient, R^2, in graph c) is 90% and in graph d) 99%, with a high significance for very low P value (P<0.001). The

analyzed measurements for August are presented in graph e) and graph f). The average water temperature in tank inside was 9.7°C, while in tank outside it was 13°C. Fishes from tank outside the economy exhibited positive allometric growth (b=3.1), while fishes from tank inside the economy exhibited negative allometric growth (b=1.17). The determination coefficient, R^2, in e) is 94% and in f) 99%, with a high significance for very low P value (P<0.001).

4. Conclusions

This study provides the importance of environment condition and diet regime in the cultured *S. letnica* growth. The depth of water, the temperature, dissolved oxygen and the optimum food intake presented a healthy growth in this fish. Fishes placed in tank outside where there was a higher temperature (10.1-13°C), a higher level of dissolved oxygen (7.5-10.4 mg/l) and were fed every two hours with pellet containing 66% protein, 15% lipids, exhibited isometric or positive allometric growth. Whereas, fishes placed in tank inside with lower temperature and dissolved oxygen exhibited negative allometric growth. In this case for *S. letnica* + 1 year smolt the best pellet were that with 66% protein and 15% lipids. Their feeding every two hours resulted in a better growth rate. The environment conditions and the diet regime in tank outside were more appropriate for smolt growth and they showed lower level of stress. In conclusion: the development of aquaculture for *S. letnica* should carefully choose the environment conditions and the more appropriate diet regime for a successful and healthy growth.

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