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FECUNDITY OF RAINBOW TROUT

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Gökkuşağı Alabalığında Yumurta Verimi

Özet: *Fırat Üniversitesi, Su Ürünleri Yüksek Okulu'nun Cip Araştırma İstasyonundaki gökkuşağı alabalıklarının yumurta verimlerinin belirlenmesi amacıyla yapılan bu çalışmada 3 ve 4 yaşlarındaki tam olgun 34 dişi balık kullanılmıştır. Yumurtaların sayısı gravimetrik, volumetrik ve doğrudan sayma ile belirlendi. Bir dişideki yumurta sayısı, bir kilogram balığa düşen yumurta sayısı ve bir kilogram balıkta santimetre küp olarak yumurta miktarı belirlendi. Değişik yaş gruplarındaki balıkların yumurta çapları da ayrıca ölçüldü.*

Bir Balıktaki ortalama yumurta sayısı 3 yaşındakilerde 2988, 4 yaşındakilerde 3228 idi. Üç yaşındaki balıklarda bir kilogram balıkta 3926, dört yaşındaki balıklarda ise 2092 yumurta bulundu. İki yaş grubunun ortalaması alındığında bir kilogram balığa isabet eden yumurta sayısı 3009 (relatif fekundite) idi ki vücut uzunluğu ile belirgin bir ilişkisi saptanamadı.

Olgun yumurtaların çapı üç yaşındakilerde 4.1 ile 5.1 mm, dört yaşındakilerde 4.7-5.2 mm arasında değişmekteydi ki bu durum balığın uzunluğu ile doğru orantılıydı.

Summary: *This study has been conducted to find out fecundity of rainbow trout raised at Cip Research station of Fisheries School, Fırat University. Thirty four fully matured female trouts of three and four years of age were used. Estimates of ova were made both volumetrically, gravimetrically and by actual count. The calculation of egg number per female fish, per kilogram and cubic centimeter of eggs per kilogram of fish were made. Eggs diameter were also measured.*

The mean number of eggs per female of three years old was 2988, for four year old was 3228. Number of eggs per kilogram of fish were 3926 for three years old, 2092 for four years old group. Relative fecundity, that is the number number of eggs per kilogram of body weight of the female, was 3009 eggs on

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the overall average. The relative fecundity did not markedly change in relation to body length.

Diameter of matured eggs varied between 4.1 *and* 5.1 *mm. in three years of age and* 4.7-5.2 *mm. in four years of age being positively correlated with the body length of female.*

Introduction

Fecundity has been defined and considered under two different meanings by various authors. First, is absolute or individual fecundity which means the number of eggs contained in the ovary of a fish or "the number of mature eggs produced by the female prior to spawning" (25). The second one is "the relative fecundity" which is "the number of eggs per unit weight or length of the fish" (25). No matter which method is used, both of them give us take knowledge of egg production of a particular species. The importance of evaluating the fecundity of fish population has been increased becasue of several reasons. Knowledge of egg production is essential in fisheries management. With the help of populasyon fecundity, it is possible to determine the commercial returns, to establish the size of brood stock and to increase the capacity of the farm if it is wanted to. The number of eggs can be increased by selection, also. Fecundity can be used as a part of systematics in radical studies, population estimation and productivity. Egg size can be correlated with size of resulting fry, which in turn is an important criterion of expected growth. The relation between the size of fish and the number of eggs they yield is very important in stripping fish or keeping brood stock for hatchery purposes, and to study fish population as well as their reproduction capacity. This subject has already been studied to some extent by several workers (17.33) in some countries. Since age and size of females maturity, differences in management techniques, feed and water quality affect fecundity of fishes it seems that will be useful to work on it and compare the results with other studies. The purpose of this study is to find out fecundity of rainbow trout raised at Cip Research Station of School of Fisheries, Fırat University.

Considerable amount of research has been carried out on life history, management and fecundity of rainbow trout. Fry (11), working with lake trout in Canada, used a complicated method based on the total weight of the ovary and the mean diameter of 10 eggs dissected from the ovary. The total number of eggs was estimated from

a conversion diagram which gave the number of eggs per gram of was based on 88 fish from two lakes. Fish fecundity has traditionally been estimated in three ways (7): 1. by direct counting of eggs in ovaries, 2. by counting or estimating the eggs when females are stripped off, 3. by counting the eggs in a given weight or volume of the ovary, determining the total weight or volume, and estimating the total eggs present after production. Pope *et al.* (29) estimated the total number of eggs by the ratio method which was described by Burrows (5). The author used water displacement method. Lindroth (21) used hatchery methods of counting eggs in which the eggs were allowed to fall into 100 small holes in a plastic plate. In this case only small sample eggs are counted. From these counts the authors were able to learn whether bias was introduced through retention of some of the eggs in the stripped fish or not. Studies on the Blackwater River trouts in 1957, 1958 and 1959 showed no evidence of differences in the method of obtaining the eggs but the results from the River Dee in 1958 showed marked differences particularly with a smaller fish. These results might be due to different experience of the workers involved and showed that the eggs should only be obtained by stripping if it is absolutely necessary. Simpson (35), Kandler and Pirwitz (18) used Stempel pipette for subsampling plaice eggs. Bagenal (1, 2), employed a cylindrical museum jar. On the other hand Pitt (28) used a whirling flask. Hickling (14) and Bridger (4) estimated the number of eggs subsampling them by area. According to Philips (27), the gravimetric methods was more accurate than the volumetric method. In some cases all the eggs in the ovary have been counted (23, 37). An automatic fish egg counter was described by Parrish et al. (26). Whereas for Leitritz (20), California volumetric method, Burrows Displacement method and Von Bayer method are the most common methods for measuring and counting eggs.

Hayford and Embody (12), described increased production of eggs in eastern brook trout, *Salvelinus fontinalis*, in the second and subsuquent generations of fish selected for high growth rate and disease resistance. Forster and Pritchard (10), have reported a positive significant correlation between the number of eggs contained in the ovaries and the total length, and the weight of the individuals of salmons. Carlender (7), gave mean 1200 eggs/lb for rainbow trout. For brook trout *(Salvelinus fontinalis)*, Vladykov (39) suggested there was a large reduction in egg number accompained by an increase in egg size as a fish rears maturity. On the other hand Scott (33), repor-

ted that variations in fecundity might also arise from direct effects of environmental conditions on individual female fish. Calhoun (6), states that "Fecundity of rainbow trout varies from less than 200 to over 9000 eggs per female, depending on fish size. Fish under one pound usually contain less than 1000 eggs, 3 to 4 pounders produce 2000 to 4000 and 10-pound females may have over 8000". Henderson (13), also working with brook trout, illustrates that the reduction is slight when the growth rate of the female increases. Incerpi and Warner (5), stated that there was a wide range in number of eggs per found of body weight within the various weight classes, but the average of egg number per pound somewhat was compareble among weight classes. Same authors claimed that mean number of eggs per pound of body weight of Landlocked salmon decreased and it increased in fish length.

According to Belding (3), in general the size of the egg depends upon the size of the apparent salmon, the larger species produce the larger egg. Also, the size of the egg varies with the salmon of different rivers. Swardsön (38), reported that fish produced large numbers of small eggs under conditions of high competitions. He also claimed that larger egg gave larger fry and the larger fry had better survival changes. Davis (8) has reported 500-3500 eggs per female fish and size diameter of eggs is about 1/5 inch. Edwards (9), gives 5.1 mm. for the diameter of rainbow trout eggs.

Material and Methods

The experiment has been carried out during spawning season, in February and March. The majority of samples were taken during March. Rainbow trouts were taken from brood fish of Fisheries School Research Station, Fırat University. Thirty four fully matured female rainbow trouts of 3 and 4 years of age were used. The fish was blotted to dry, and its total length measured to the nearest milimeter, weight to the nearest gram. Fish were dissected and all eggs were tataken out on a filter paper to take the water off, and the measurement of the dry eggs was made and recorded. Estimation of numbers of ova, were made both volumetrically, gravimetrically and by actual count (8, 19). All eggs were seperated from the ovarian tissues before measusurements were made. Then, a sample of 50-70 g. was taken and weighed seperately. Beside this, all eggs and a sample of 60-80 ml. were measured in a graduated cylindir. The calculation of egg number per female fish, per kilogram and cubic centimeter of eggs per kilogram of fish were made.

The fecundity was examined in a total of randomly sampled 34 rainbow trouts whose body length varied between 410 and 542 mm and body weight between 705 and 1837 grams. Twenty females were 3 years of age and fourteen were 4.

The relative fecundity of a female fish was given per kg. of body weight .Equations of linear regression were used to express the correlation between the number of eggs and body weight and length of the female (absolute fecundity).

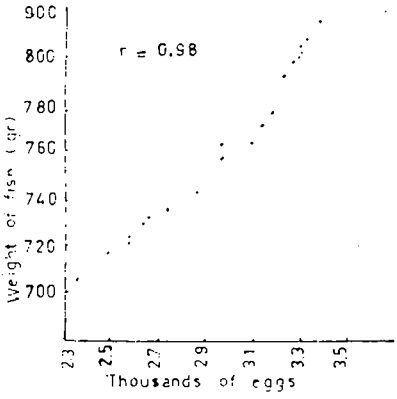
For measuring egg diameter, 10 eggs were arranged in a straight line in a close apposition and their total diameter was measured with a sliding calipers to the nearest tenth of milimeter. Also, randomly sampled fifty eggs were measured seperately. First procedure was repeated three times for each fish. Diameter of eggs was thus determined by dividing the total diameter by the number of eggs measured. Minute and yolkless ova were not counted.

Results

The results obtained from trouts are given in Table 1. The mean number of eggs per female of three years class was 2987.6, for four years class was 3227.7. Although there is an increase of about 7.9 % in four years class (absolute fecundity), relative fecundity decreased 48 %. A wide range in number of eggs per kilogram and total number of eggs per fish are apparent.

Table 1.Absolute and relative fecundity end egg size of female rainbow trout

Measurment	3 yrs. old fish		4 yrs. old fish	
	Range	Mean	Range	Mean
Weight of fish (g.)	705–812	761.1	1316–1837	1540.5
Length of fish (mm)	410–444	426.0	514–542	526.0
No. of eggs per kg of fish	3348–4206	3926.4	1986-2401	2092.1
No. of eggs per fish	2360–3415	2987.6	2613–4410	3227.6
Cubic centimeters eggs per kg. of fish	70.9–88.1	81.2	59.3–129.4	111.5
Egg size (mm)	4.1–5.1	4.7	4.7–5.2	4.9



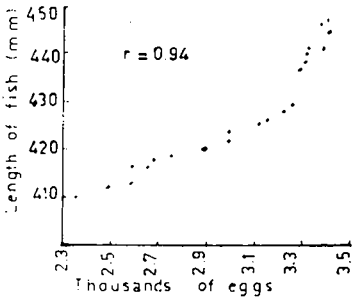
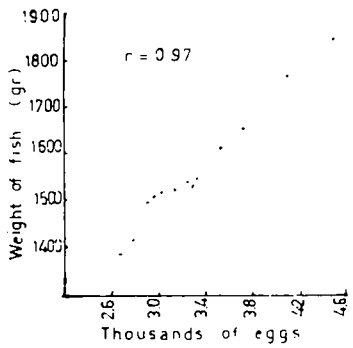


Fig. 1. Mean number of eggs and weight of 3 yrs old rainbow trout.
Fig.2. Mean number of eggs and length of 3 yrs old rainbow trout



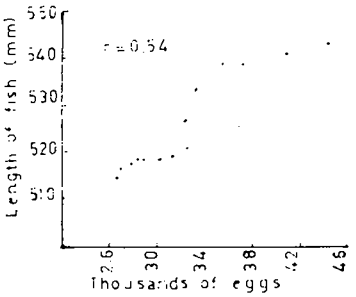


Fig.3. Mean number of eggs and weight of 4 yrs old rainbow trout.
Fig. 4. Mean number of eggs and length of 4 yrs old rainbow trout.

There was a tendency for the mean number of eggs per kilogram of body weight to decrease with increase in fish weight and length. The estimated number of mature eggs in 3 years old 20 trouts, 410 to 444 mm long, ranged from 2360 to 3415. Number of mature eggs in 4 years old 10 trouts, 514-542 mm long, ranged from 2613 to 4410. The correlation between the number of eggs and the body length of female (absolute fecundity) was linear (Fig. 1-4). Relative fecundity, i.e. the number of eggs per one kilogram of body weight of the female, was 3009.3 eggs on the overall average. The relative fecundity did not markedly change in relation to body length (Table 1).

The average size (diameter) of the eggs of rainbow trout in the period of spawning varied between 4.1 and 5.1 mm in three years of age and 4.7-5.2 mm in four years of age being positively correlated with the body length of female. Fish size and weight have a direct bearing on the size of the eggs produced. The mean diameter for 3 years was 4.7 mm and for 4 years was 4.9 mm.

Discussion

Different authors define population fecundity in various ways. According to Ivlev (16), population fecundity means the average number of eggs deposited by one female of a given species. Johansen (17), refers to population fecundity as the number of eggs which a population produces in the conditions of a definite body of water. Scott (33), states that the term "fecundity" usually refers to the numbers of mature eggs produced by a fish at spawning. Shirkova (35), claims that the definitions of population fecundity of these authors differ, in essence they both present a method of evaluating not absosolute but relative fecundity, since both use the relative numbers of females in the samples for determining this value. Scott's (33) definition seems to be more logical, since the mature egg is the goal of fisheries. Unmatured or dead egg is not important to hatcheriest and to scientists. For this reason, the authors idea was prefered and the number of mature eggs just before spawning was used.

The fecundity of fish, defined as the number of ripening eggs in the female prior to the next spawning period, may be determined for a number of purposes (30). For whatever purposes fecundity is determined the methods are basically similar and fall conveniently into three phases: 1. Catching an unbiased sample, 2. Estimating the number of eggs, and 3. Analysing the results in relation to the other population statistics (30). All phases mentioned above were used during this study.

Fecundity is an especially interesting topic in the Salmonidae because of comperatively small number of large eggs suggests a demonstrable relation between the reproductive potential of the spawning stocks and the number of young surviving (31).

The value of fecundity studies has sometimes been questioned and Russel (32) states that there is no necessary connection between the number of eggs produced in a single year and the number of fry

that survive, bur rather it is the survival of the eggs and larvae that determines the year class strength.

The number of eggs produced by trout varies greatly with the species and the size of the individual fish. Some writers (7,10) have attempted to find a direct correlation between the number of eggs and the weight of the females, but they have been only partially successful. In some females, the number of eggs per kilogram of fish may be nearly twice that produced by others. Ordinarily, small trouts produce more eggs per kilogram of fish than older and larger trouts do, but to this there are numerous exceptions. Furthermore, eggs from older fish are usually larger than those of young trout at the first spawning. In this study the mean number of eggs in three years old fish were slightly fewer and smaller than four years old. The number of eggs per kg. of body weight were much higher in three years old female. Within the year there were positive correlation between the number of eggs and the weight and the total length of individuals as Forster and Pritchard (10) reported. These results verify the authors findings.

In general, rainbow trout yield from 500 to 3500 eggs per female, depending on the age and size of the fish (8). According to the same author eggs of rainbow trout have an average diameter of about 1/5 inch. During this study, the maximum number of eggs was 3415 per fish in three years class and 4410 in four years class. The mean size of eggs were 4.7 and 4.9 mm. relatively. The results obtained are more than Carlender's (7) but verify Davi's (8) and Calhoun's (6) findings. As Scott (33) reported variation fecundity might be due to environment.

Smith (36), studying egg production in *Salvelinus fontinalis*, stated that the number of eggs was related to the weight or volume of the fish rather than to length. Same conclusion was achieved during this study. According to Nicholls (24), in general, where a sufficient size range has been studied within a species, egg numbers increase as the cube of the length or better. Author reported that rainbow trout produce a great number of eggs in relation to their length and weweight than do brown trout. In all species there is an increase in the numbers of eggs with the length of the fish (25). On the other hand Stanislav (22), claimes that relative fecundity in relation to body length slightly decreases with increasing body length. The fecundity in a single population may undergo considerably fluctuations in relation

to the supply of nourishment. Population with a greater food supply, usually has a larger fecundity (25). With the more fecund species it is more reliable to count the number of eggs in a series of replicate subsamples. It is easy to make a gross error when counting several thousand eggs, but replicate subsamples of a few hundred check against each other and yield a more constant and reliable results (30). Typical results of a fecundity investigation have shown that fecundity is approximately proportional to the cube of the length. or linearly proportional to the weight or to the age of the fish. Age is of only limited value in predicting fecundity, while length and weight are of about equal value. Since environmental conditions and feeding will effect the egg yield, the age of fish does not have an apparent value. There is always considerably variability even between fish of the same length or weight, and very great variability among fish of a given age. It is therefore essential that a statistical analysis should be performed on the data, particularly when investigating possible fecundity differences between years or localities (30). Some authors (25) have expressed their results as "relative fecundity" i.e. the number of eggs per unit weight of fish. However, the individual and relative fecundity are not characteristic of the reproductive capacity of the population, because the fecundity, depends not only on the individual fecundity but also on the time of onset of sexual maturity, and on the periodicity and frequency of spawing throughout the life of the individuals (25). If the weight includes the gonads this may lead to a spurious correlation, while if the gonad weight is not included difficulties may arise if there are marked changes in condition either as the spawning season approaches or from year to year or place to place (30).

In some cases fecundity may have to be determined by stripping the eggs from the fish so that neither fish nor eggs are killed, but it is more satisfactory to dissect out they ovary and estimate the number of either fresh or preserved eggs (30). When eggs are obtained by stripping it is to be expected that some eggs will be left in the ovaries. Since some eggs will be left in the body cavity of fish after stripping, the best way is to kill fish during spawning period and get the actual counts of all mature eggs. The probability and percentages of error will be minimum by this way. For this reason Scott's (33) definition seems to be more logical.

In general, the size of the egg depends upon the size and age of the parent fish, the larger specimens producing more and larger eggs.

Egg size also varies among different strains of domestic brood stock, and among wild fish in different waters. It is reasonable to assume that competition among fry gives the larger fry a better chance for survival and faster growth. Hence, in selecting brood stock there is some advantages in selecting for larger eggs. Size, however, can be attained only at the expense of number. There is, therefore, some point at which, on the average, the forces favoring size are balanced by those favoring number. Mt. Whitney Hatchery spring-spawning rainbow brood stock average 1553 eggs when two years old and 2210 eggs at three years of age. The size of eggs increased by 40 percent between the second and third year of the female's life and the number of egg produced increased by 42 percent. The number of egg per fish is 2600 for all spawn two years of age (20).

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