

Reproduction biology of chub living in Lake Hafik

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Abstract

In this study, the reproductive biology of chub population in Hafik Lake was investigated. 242 samples were caught between April and November 2009. The age of *S. cephalus* samples were found to range between I-VIII; in addition, 153 of them were female and 89 were male. Their fork lengths changed between 114-332 mm, and body weights were between 22.5 and 550.3 g. Male specimens were determined to reach sexual maturity at II and III age, while females reached at III and IV years of age. The smallest female individual at sexual maturity had 114 mm of fork length and 27.3 g, while the smallest male at sexual maturity had 118 mm of fork length and 24.2 g. The mean gonadosomatic index of male and female specimens were found highest in April (12.33, 8.02) and May (8.37, 4.64) and minimum in August (2.39, 1.22). Egg diameters of chub individuals were measured between 343 μm and 1900 μm . The egg number in per one gram ovary was maximum in August, and minimum in April and May. *S. cephalus* was determined to lay eggs in Hafik Lake towards the end of April, which continued until the end of July. Maximum fecundity in population was observed as 151302 in the specimen at the age of VI.

Keywords: Chub, gonad development, Hafik Lake

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Introduction

Reproductive characteristics of a species has become fundamental on fisheries biology studies (Kara, 1992; Sarihan, 1993). The reproductive pattern of a species is based on several studies including oocyte size measurement, ovarian organization, maturity staging and gonadosomatic index (Lagler, 1956; West, 1990; Stoumboudi *et al.*, 1993). Macroscopic maturity staging and gonadosomatic index are the preferred methods for reproductive studies in Turkey as they are without any cost

Chub, a typical cyprinid species, has a wide distribution area in Europe and Asia. They have rich populations in many lakes and rivers in Turkey (Slastenenko, 1955; Geldiay & Balık, 1988). High ecological tolerance of the species is one of the possible reasons behind its wide geographical distribution (Arlinghaus & Wolter, 2003). Chub is accepted as rheophilic (Schiemer & Waidbacher, 1992) and lithophilic (Balon, 1975) species. Its population in lake migrates to rivers for spawning in May and June. They lay their eggs on gravels bigger than 5 mm in shallow waters with 0.15-0.75 m/s of stream speed and 0.1-0.3 m of depth. (Nikolsky, 1963; Cowx & Welcomme, 1998). Some studies have been performed on reproductive characteristics of various populations of chub found in Turkey (Erk'akan & Akgül, 1985; Şen, 1988; Ünlü & Balcı, 1993; Ekmekçi, 1996; Altındağ, 1997; Karataş, 1997; Yerli *et al.*, 1999; Ünver, 1998; Türkmen *et al.*, 1999; Şaşı & Balık, 2003; Şaşı, 2004; Kalkan *et al.*, 2005; Koç *et al.*, 2007; Saygun, 2007).

Hafik Lake is a typical cyprinid lake. *Cyprinus carpio*, *Squalius cephalus*, *Alburnus chalcoides* and *Chondrostoma nasus* are dominant fish species. Commercial fishing and crayfish hunting are performed in the lake. No study has been carried out on fish other than the study of Cengizler (1987) investigating the biological characteristics of *Cyprinus carpio*.

With the present study aiming to determine reproductive characteristics of chub in Hafik Lake Study results pave the way for the studies on ecology, reproduction, nutrition and hunting of the species.

Materials and methods

General Characteristics of Hafik Lake

Hafik Lake is located 36 km away from Sivas and 3 km from the city centre of Hafik County with a 1290 m elevation from sea level, and it is surrounded by Haştar Height in east, Tığ Height in west, Mağraönü Height in north and Böğürme Height in south. Hafik Lake has a karstic characteristic. Lake has a heart shape. Surface area of lake is 75 ha, and its volume is 2.250.000 m³. The lake is located in the Kızılırmak River basin. Both rain water and ground water enter to the lake (Ceyhan, 1987). Its mean depth is 2 m, and it is also eutrophic (Çepken, 2008) and open lake from limnological respect (Fig. 1). It is the second biggest natural lake in Sivas, and presents a significant nutrition, shelter and reproduction area for aquatic birds. There is an island in the north-west part of the lake, and its surrounding areas are completely covered

by agricultural lands. In addition, there are excursion spots and three fish restaurants

in the lakeside.

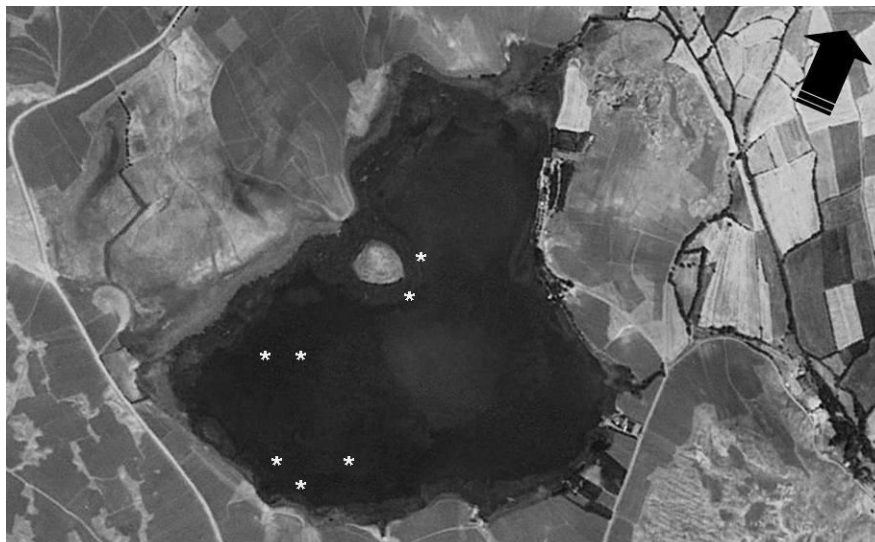


Figure 1: Hafik Lake (*; fish sampling areas)

Collection and Evaluation of Samples

Certain physical and chemical properties (depth, temperature, dissolved oxygen, pH and electrical conductivity) of lake water were determined by direct measurements on lake using portable water quality devices (Consort, C 932 °C, mV, O₂, pH meter; Speedtech Depthmate Sounder SM-5).

Fish samples were collected by monthly sampling during 8 months between April and November 2009. Gill nets and trammel nets of different lengths and heights with 15x15, 18x18, 20x20, 24x24, 32x32 and 50x50 mm of mesh sizes were used in the collection of fish samples. In order to determine the diagnostic characteristics of the species, 36 individuals of the same age group were examined with respect to 28 metric characters and 30 individuals were examined regarding 13 meristic characters. For the biological analysis, fork and total lengths (± 0.1 mm) of each fish sample

were measured with digital caliper, and fish were weighted with a 0.1g sensitive electrical balance. Scales were used for age determination (Lagler, 1956). Olympus BX51 binocular microscope, DP 70 digital camera and monitor systems were used for annuli count. Sex determination was performed by the macroscopic examination of gonads. To define the sexual maturity, West (1990) criteria have been used. Maturity ages of female and male individuals were specified. The smallest size class in which 50% of individuals were sexually mature (Mat₅₀) was determined to provide estimates of the sizes of sexual maturation of female and male individuals. Testis and ovaries were removed and their weights (± 0.1 g) were measured using Sartorius BL 3100 portable scale. Monthly changes in the mean gonad weights of female and male individuals were determined. The mean gonadosomatic index (GSI) for both

sexes was calculated from the equation $GSI = (w_0/W_t) \times 100$ where w_0 is gonad weight and W_t is body weight (West, 1990).

Egg count was performed by removing 0.5 and 1 g of fragments from the central parts of ovaries. Approximately 50 egg diameters (μ) of each sample were measured using micrometric ruler in Olympus BX51 binocular microscope, DP 70 digital camera and monitor system. Total fecundity was estimated by the gravimetric method: the mean number of mature oocytes in per one gram ovary was estimated and multiplied by the total ovarian weight (Kara, 1992).

Reproduction time of *S. cephalus* in Hafik Lake was determined by analyzing monthly changes in gonad weights, gonadosomatic index, egg diameter and egg number in per one gram ovary.

In the evaluation and statistical analysis of all data, SPSS software for Windows (version 14.0, SPSS Inc., Chicago) was used.

Results

Physical and Chemical Characteristics of Hafik Lake

Certain physical and chemical characteristics of the species habitat are determined. Maximum depth was measured using echosounder as 6.8 m in the southern part of Lake, and the depth was found to change between 0.8 and 2.0 m. Water temperature was measured between 4.0-22.5 °C, dissolved oxygen was between 10.2-6.7 mg/L, and pH was around 8.0. Individuals of chub began to spawn in parallel with the increasing temperature from 10.5 °C in April to 20.7

°C in May. Dissolved oxygen was found as 9.0 mg/L during this period.

Diagnostic Properties of Chub

In order to determine the diagnostic characteristics of the *S. cephalus* in Hafik Lake, 28 metric characters of 36 individuals and 13 meristic characters of 30 individuals were investigated. Fork lengths of the samples changed between 142.0 mm and 267.5 mm. Head lengths of the samples were longer than body heights. Upper jaw (12.93 mm) was longer than the lower one (10.95 mm). Standard size was 4.3 times longer than body height, 4.1 times than head length, and head length was 5.8 times longer than orbit diameter. The number of scales on line lateral was found to change between 39 and 45. The mean number of gill rakers was 10. Pharyngeal teeth were in the order of 2.5-5.2. Fin formulations were recorded as D: (II) III / (7) 8 (9), A: II (III) / (7) 8 (9), P: I / (12) 15 (16), V: II (III) / (7) 8 (9).

Sex, Age, Size and Weight Composition

In the study, a total of 242 chubs were analysed. 153 of them (63%) were females and the 89 (37%) were males. Female:male rate in Hafik population was determined as 1.72:1.00. Chub samples were found to have eight age groups (I-VIII). There were 2, 44, 65, 71, 27, 24, 7 and 2 individuals in each age group; respectively. All the individuals in VIII age group were males. The number of female individuals was higher than males in all age groups (except II age group). In the examination of all samples,

representation rate of the individuals in III and IV age groups in population were found 56.20%. Fork lengths of *S. cephalus* samples changed between 114 mm and 332 mm. The smallest lengths of female and male individuals were 114mm and 118 mm, and the maximum lengths were 329 mm and 332 mm, respectively. Body weights changed between 22.5 g and 550.3 g. The smallest weights of female and male individuals were 25.4 g and 22.5 g and the maximum weights were 434.6 g and 550.3 g, respectively.

Ovary and Testis Morphology

Mature ovaries of samples had a granulose appearance. Blood vessel became apparent prior to ovulation. In the samples examined at the end of April and May, eggs were easily discharged upon touching the abdomen of fish. Fats began accumulating around the gonads and the intestines from the beginning of October. Ovaries were generally in similar sizes. Right ovary became completely fused in the samples of VI age group examined in July. Right ovary was 20.1 g in the samples of VII age group in November, while the left ovary was 4.6 g. Ovaries were gold-colored or dirty yellow-colored in the adult female individuals examined in April and May. On the other hand, gonads had generally gray or mould green colors in the period following August.

Testicles had an ungranulated, smooth, and even appearance. The ventral side of gonads with wider dorsal regions facing body cavity had a sharper appearance. Similar to ovaries, testicles had a pair of sac-shaped organs. One of the testicles was

observed to become partially or completely dull in some samples. Left testicle was observed to be completely dull in an individual of VII age group in April. Testicles had a mixed color of dirty white and milk white in reproductive period. When the mature fish was taken from fishing nets, semen was observed to flow easily in this period. On the other hand, testicles were generally cream or pink-cream colored in autumn.

Reproduction Characteristics

Sexual Maturity Age

No mature individual was observed in females of I age group. Approximately 30% of the individuals of II age group were mature, while this rate was 65% in III age group. The rate of young individuals of IV age group was reduced to 4%. The rate of maturity males was about 20% in I age group, while it increased to 75% in II age group (Table 1). The smallest mature female individual was 11.4 cm (fork length) and 27.3 g, and the male was 11.8 mm (fork length) and 24.2 g.

Reproduction Period

Gonadosomatic Index

Mean, minimum and maximum gonadosomatic index values are presented in Table 2, and monthly changes are shown in Fig. 2. Mean gonadosomatic index values of both female and male individuals were highest in April and May (12.33, 8.37 and 8.02, 4.64). The index value was lowest in August and started to rise from September to April. Variation coefficient of mean values was calculated between 20.58 and 69.41.

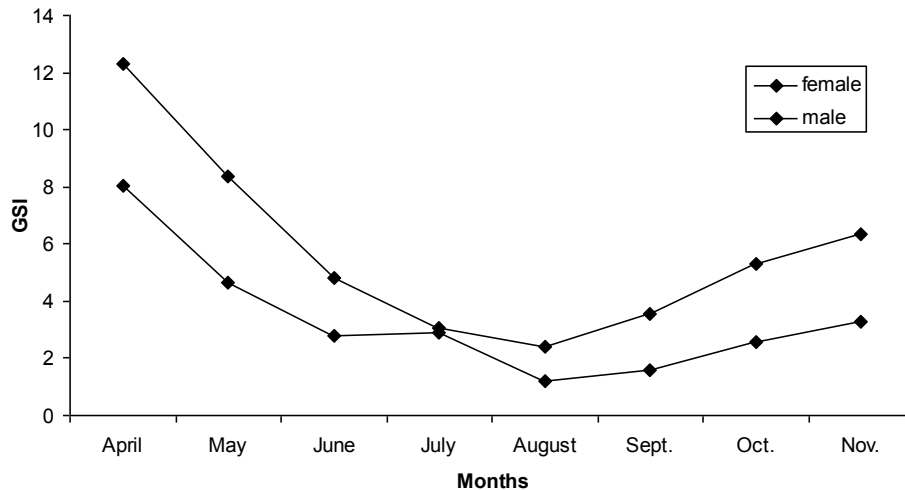


Figure 2: Monthly changes of gonadosomatic index values of *S. cephalus*

Gonad Weight

Monthly mean values of ovary and testis weights were calculated in chub population and presented in Table 3. The highest and lowest ovary and testis weights were found in April and August. Ovary weight of an individual at VI years of age examined in April was determined as 83.50 g. The highest testis weight (10.10 g) was determined in a IV years old individual. Gonads entered re-development process after September and increased their weights.

Egg diameter and egg number in per one gram ovary

Monthly changes of egg diameter and the number of egg in per one gram ovary in *S. cephalus* population were determined and given in Table 4. Egg diameter was measured between 343 μ and 1900 μ in chub samples. The mean egg diameter was determined 1102 μ and 1237 μ in April and May, respectively, and it was lowest in August. The relation between ovary weight

Egg Fertility

and egg diameter was given in Fig. 3, while the relation between the number of egg in per one gram ovary and egg diameter was given in Fig. 4. Increases in ovary weight and egg diameter followed a parallel path (Fig. 3). The mean egg diameter was found 1102 and 1237 μ in April and May when the ovary weight was highest. A gradual decrease was measured until August when both the ovary weight and egg diameter (602 μ) were at their minimum levels.

There was an inverse proportion between the number of egg in per one gram ovary and egg diameter (Fig. 4.). There were around 969-991 eggs counted in per gram ovary in April and May when the egg diameter was highest. Egg number was at its maximum level in August and egg diameter gradually decreased until November in parallel with the egg development.

Distributions of the mean, minimum and maximum egg numbers of *S. cephalus* and relative increases in egg numbers

according to age groups were given Table 5.

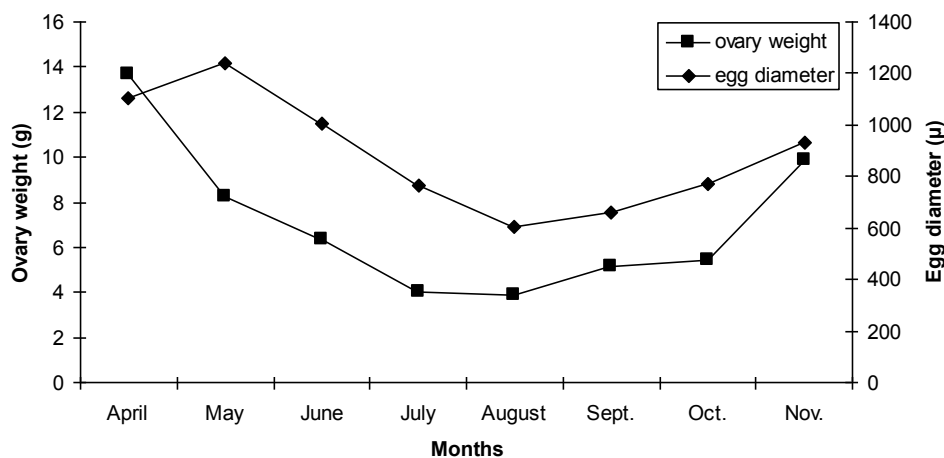


Figure 3: Relationship between ovary weight and egg diameter of *S. cephalus*

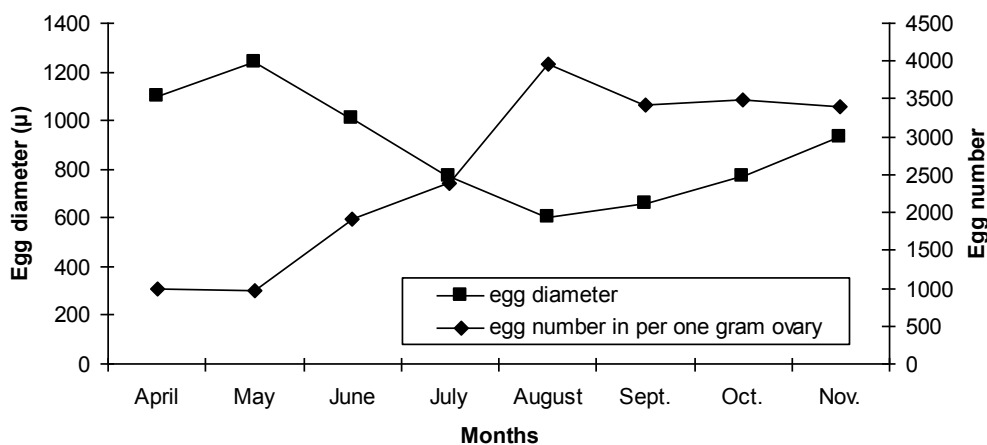


Figure 4: Relationship between egg diameter and egg number in per one gram ovary of *S. cephalus*

Egg Fertility

Distributions of the mean, minimum and maximum egg numbers of *S. cephalus* and relative increases in egg numbers according to age groups were given Table 5. Maximum value of total fecundity in chub population was determined as 151302 in the individual of VI age group. Mean values of age groups changed between 9319 and 55139 eggs. The highest

relative increase in egg number (108.92%) was found in the transition from III to IV age group. This rate was lowest in VII age group. Changes in egg numbers with age were given in Fig. 5. It was concluded that fecundity tended to increase in parallel with age. Correlation coefficient was calculated as 0.9705.

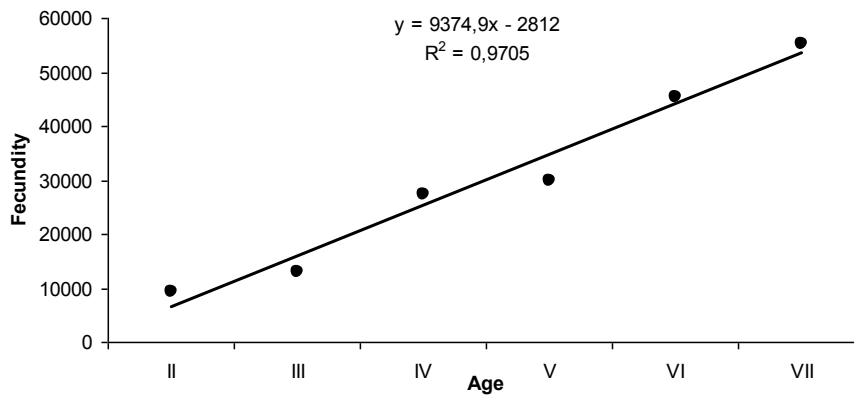


Figure 5: Relationship between age and mean fecundity of *S. cephalus*

Discussion

Morphological and diagnostic characteristics of *S. cephalus* inhabiting Hafik Lake were compatible with the morphological and diagnostic characteristics of population defined in their distribution areas by Erk'akan (1981), Geldiay & Balık (1988) and Ünver & Erk'akan (2005). 63% of 242 chub samples in the study were composed of female individuals and 37% were male individuals. Female:male ratio of samples was calculated as 1.72:1.00. Female:male ratios were reported as 0.82:1.00 in Müceldi River (Öztaş & Solak, 1988), 1.00:2.15 in Tödürge Lake (Ünver, 1998) and 1.00:1.45 in Karasu Stream (Saygun, 2007). Female:male ratio could be different from the expected 1:1 rate due to the natural and fishing related deaths among sexes, caused by hunting in reproductive period and changes in ecological conditions (Sarıhan, 1993; Lagler, 1956; Nikolsky, 1963). Eight age groups (I-VIII) were determined for chub population in Hafik Lake. Rate of young individuals was found higher compared to the rate of aged individuals. The maximum age reached by the population of the species in Turkey changed between V and X years (Ekmekçi,

1996; Ünver & Tanyolaç, 1999; Balık *et al.*, 2004, Saygun, 2007). In chub population in Hafik Lake, male mature individuals were observed at II-III while females at III-IV (Table 1). Male individuals in Müceldi Stream at III, and females at III-IV years of age (Öztaş, 1988); in addition, in Sarıyar Dam Lake reached sexual maturity at III-V years of age (Ekmekçi, 1996), males in Tödürge Lake at II-III years of age, females at III-IV (Ünver & Tanyolaç, 1999), males in Karasu River at II, females at II-IV (Erdoğan *et al.*, 2002), in Sır Dam Lake at II (Kara & Solak, 2004), in Topçam Dam Lake at II (Şaşı, 2004), in Karakaya Dam Lake at III (Kalkan *et al.*, 2005), and in Karasu Stream at III years of age (Saygun, 2007). As male individuals grow faster than females in juvenile periods, they are known to reach sexual maturity one or two years earlier (Weatherley & Gill, 1987). Nutrient amount, water temperature, photoperiod and elevation of the habitat of the species are among the biotic and abiotic factors that can directly affect the sexual maturity age (Nikolsky, 1963; King, 2007). Gonadosomatic index values of female and male individuals were found highest in April and May, and

it was lowest in August (Table 2, Fig. 2). Similarly, the lowest and highest weights of ovary and testis were determined in April and August (Table 3). The mean egg diameter was found highest in April and May, and it was lowest in August. There were 991 and 969 eggs on average in per one gram ovary in April and May when the egg diameter was highest and egg number was reached at its maximum level in August (Table 4, Fig. 4). As known, gonadosomatic index and egg diameter reach their maximum levels in the beginning period of spawning (Lagler, 1956; Nikolsky, 1963). When the monthly changes of gonadosomatic index, gonad weight, egg diameter and the number of egg in per one gram ovary were investigated, it was concluded that spawning in *S. cephalus* population began towards the end of April and continued to the end of July. Egg diameter values and reproduction periods of chub were determined as May-June in Savur Stream (Ünlü & Balcı, 1993), 0.58-1.032 mm and April-June in Sarıyar Dam Lake (Ekmekçi, 1996), 0.86-1.48 mm and May-June in Akşehir Lake (Altındağ, 1997), 0.46-1.04 mm and May-July in Tödürge Lake (Ünver, 1998), 0.92-1.45 mm and May-July in Aras River (Türkmen *et al.*, 1999), 0.39-0.74 mm and March-April in Topçam Dam Lake (Şaşı, 2004), 0.70-0.88 mm and May-July in Karakaya Dam Lake (Kalkan *et al.*, 2005), April-May in İkizcetepeler Dam Lake (Koç *et al.*, 2007) and May-July in Karasu Stream (Saygun, 2007). Geographic, climate and ecological conditions as well as the increasing temperature can directly or indirectly affect the beginning and ending periods of reproduction (Weatherley & Gill, 1987; Nikolsky, 1963). In parallel with the

increasing water temperature in Hafik Lake from 10.5°C in April to 20.7°C in May, chub individuals were observed to begin laying eggs. Dissolved oxygen amount was measured as 9.0 mg/L in this period. Water temperature in the reproductive period of species changed between 12-18°C in Müceldi Stream (Öztaş, 1989), 15-23°C in Savur Stream (Ünlü & Balcı, 1993), 16-23°C in Aras River (Türkmen *et al.*, 1999) and 16-18°C in İkizcetepeler Dam Lake (Koç *et al.*, 2007). Total number of egg in ovary is named as fecundity, which demonstrates the reproductive capacity of population (Sarıhan, 1993; Lagler, 1956; Nikolsky, 1963). The mean number of eggs was found to increase with age in chub samples in Hafik Lake (Fig. 5). Maximum fecundity in population was determined as 151302 in VI age group. Fork length of this fish was measured as 252 mm. The mean values of egg numbers changed between 9319 and 55139 according to age groups. The maximum relative increase in egg number (108.92%) was observed in the transition period from III to IV age groups. This rate was reached to its lowest level in VII age group (Table 5). Egg fertility rate rapidly increased in the initial periods of sexual maturity; however, fecundity increase rate slowed down as a result of ageing (Nikolsky, 1963). Total number of eggs in the geographic distribution areas of species was reported to change between 4349-51137 (Öztaş, 1989), 13269-59200 (Ekmekçi, 1996), 9679-106227 (Altındağ, 1997), 1158-28664 (Ünver, 1998), 3391-17187 (Türkmen *et al.*, 1999), 5012-25000 (Erdoğan *et al.*, 2002), and 9142-53100 (Şaşı, 2004). Differences between the stock size, nutrient amount in the habitat,

age and length distributions of the species in different geographic populations of the species as well as the ecological and geographic conditions are factors that could directly or indirectly affect the egg fertility of the species (Nikolsky, 1963; King, 2007).

Considering the findings on reproduction period, it is considered that fishing ban should be set to cover the period between mid April and July with regard to the changes in water temperature to coincide with the spawning period in order to sustain and benefit more efficiently and economically from the chub population in Hafik Lake.

Chub is accepted as a rheophilic (Schiemer & Waidbacher, 1992) and lithophilic species (Balon, 1975). Its population in Lake migrates to rivers in May and June for ovulation. They lay eggs on gravels bigger than 5mm in shallow waters with 0.15-0.75 m/s of flow speed and 0.1-0.3 m of depth (Nikolsky, 1963; Cowx & Welcomme, 1998). Sexually mature chub individuals in Hafik Lake were observed to migrate to canals in Sultanpınarları district and lay their eggs in this area. Fish larvae were determined in the same area a few weeks later the ovulation. Water depth in this place was measured around 15 cm.

One of the regions where the species migrates in reproduction period is the Koru Stream located in the eastern part of the Lake. As the canal which is found at the outlet of lake and provides the connection between Hafik Lake and Koru Stream has been closed down by Hafik District Governorship, it was observed that chub individuals were prevented from entering into stream for spawning. This canal should be re-opened to allow the

spawning migration of chub as in the past years to sustain the continuity of the species.

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