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Catch composition, length frequency and biomass of commercial carps in Zayandehrud dam, Isfahan Province, Iran

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Abstract. *Abbasi MR, Paighambari SY, Pouladi M, Ghorbani R. 2017. Catch composition, length frequency and biomass of commercial carps in Zayandehrud dam, Isfahan Province, Iran. Biodiversitas 18: 939-944.* The reservoir of Zayandehrud with an area of 4800 hectares due to its economic role is one of the important lakes in Isfahan Province. This study was performed from September 2015 to March 2016, to evaluate catch composition, length frequency and biomass of carps for sustainable utilization of fish resources. Sampling operations were performed using gill nets with mesh sizes including 40, 50, 60, 70, 80, 90, 120, and 150 mm (stretched) with a length of 1 to 3 km seasonally. A total of 617 fish with a total weight of 1109.7 kg were caught. The important species which were caught by fishing operations were including common carp (*Cyprinus carpio*), silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Hypophthalmichthys nobilis*), grass carp (*Ctenopharyngodon idella*) and mesopotamian barb (*Capoeta damascina)*, respectively. Due to natural reproduction season (spring, in July), the fishing season usually starts from August to the end of winter. Common carp with 292 pieces (47.32%), silver carp with 87 pieces (14%) and mesopotamian barb with 221 pieces (35.81%) had the most abundance; whereas crucian carp with 4 pieces (0.64%) and grass carp with 1 piece (0.16%) showed the lowest abundance. Also as the main species of study, highest length ranges of caught common carps were in the range of 38-45 cm and 46-50 cm in autumn and winter, whereas highest length ranges of caught silver carps were in the range of 56-86 cm and 48-54 cm in autumn and winter. Length - weight relationships of carp showed an isometric growth model that indicates homogeneous growth in fish.

Keywords: Carp fish, catch composition, length frequency, Zayandehrud dam, Isfahan

INTRODUCTION

Protein sources for human consumptions are provided through agriculture, livestock and aquaculture production. Development of fisheries in a lake or reservoir water through of production of natural water sources, determine suitable species of fish for release, ratio and density appropriate, the use of appropriate technology, protection of the beds spawning, prevent the escape of fish and control of fishing is possible (Sirvastava 1992). Despite the increasing pressure of population growth on existing limited resources is entered, the need for more recognition of the characteristics of water resources and fisheries in order to apply proper management is felt (Abbasi 2010).

In terms of geographical and climatic characteristics, Isfahan province has vast potential for aquaculture development, such that there are vast possibilities for the development of multi-purpose ponds for fish farming, saltwater, and brackish aquaculture development, and finally cold water fish culture. Lakes and water resources of this province can create conditions for intensive fish production and these facilities can be used to create suitable habitats to develop and maintain of fish stocks (Fisheries Department of Isfahan 2014).

There are more than 20 cases of these natural resources and lakes in Isfahan province. One of the potential and important lakes is Zayandehrud dam in Isfahan province which is located at distance of 110 km of the west of Isfahan in Chadegan city. The primary purpose of the dam is water supply to Isfahan which lies 88 km to the east. It also supports a power station with an installed capacity of 55 MW (Jeroen and Droogers 2004). Over the last 10 years, an annual average of around 180 thousand pieces of fish in this lake has been released by the Fisheries Department of Isfahan (2014) and the annual fishing is about 300 tons in this lake. These amounts of harvests already are harvested by more than 250 professional fishermen who live in the villages along the lake. Numerous studies for evaluation of aquatic life in lakes have been done in Iran in recent years. In assessing of fish stocks in the inland water sources in Iran can refer to researches on released and endemic fish stocks in Aras lake dam (Qaninezhad and Pour Gholam Moghadam 1995), Mahabad dam (Abdolmaleki 2004), Tahm dam (Mirzajani 2008), Choueir and Mirzakhanlou dam (Mirzajani 2009), Lar dam (Salavatian et al. 2014) and Golbolagh reservoir (Mohammadi et al. 2016).

Due to importance of the lake in terms of fish production and issuance of permits to harvest and lack of the basic information about the store and harvest the catch, growth and density, It is necessary to survey data, the catch composition, density, length frequency and estimate the amount of biomass of carp fishes in this study. The main purposes of this research are a determination of the catch composition, biological conditions of carp species and estimation of commercial carps biomass in Zayandehrud reservoir.

MATERIALS AND METHODS

Sampling fish from three stations, using monofilament gill net with length of 1 to 3 km and 4 to 15 meters height and mesh sizes of 40 to 150 mm (40 mm mesh size - 1 roll, 60 mm mesh size - 2 rolls, 60 mm mesh size - 2 rolls, 70 mm mesh size - 2 rolls, 80 mm mesh sizes - 2 rolls, 90 mm mesh sizes - 1 rolls, 100 mm mesh size - 1 rolls, 120 mm mesh sizes - 1 roll, 150 mm mesh size and 1 roll) was conducted in collaboration with members of the fishing cooperative.

Stations distances with each other were around 2.5 to 3 km. Stations and nets characteristics in sampling period were included: Station 1: gill net with 1500 m length (100 m net length with 70 mm mesh size, 1000 m net length with 90 mm mesh size, 350 m net length and 100 mm mesh size, 50 m net length with 80 mm mesh size) and 8 to 18 net height and 15 m lake depth; Station 2: 600 m net length and 9 m net height and 40 m water depth and net mesh size including: 70, 80, 90, 100 and 120 mm; Station 3: 2000 m net length and 6 m to 18 m net height and 30 m water depth and net mesh sizes including: 60, 70, 80 and 120 mm.

Sampling and collecting of information using gill nets of fishing cooperatives, during 15 days in autumn and 15 days in winter were done. Also, fish scales for determination of fish ages from below of dorsal fin were taken, and using Microscope with magnification 50 were observed and annual growth circle were counted in the laboratory (Chugunova 1959). For length classification of target species (Carp fishes), samples were classified according to Sturges (1926) formula:

$$R = (Max - Min) + 1_{\#}$$
$$K = 1 + 3.3 \log n_{\#}$$
$$C = \frac{R}{K}$$

Where *R* is the number of samples, *K* is the number of categories, and *C* is classes' gap in fish, the length (cm) - Weight (g) is usually shown as follows:

$$W = aL^{b}$$
#

Where *W* is total weight in grams and *L* is the total length in cm. Also to test for growth pattern, Pauly-Monero test and for the test of allometric and isometric significant growth and for determining the b significant value Pauly test was used (Biswas 1993).

$$t = \sqrt{n-2} \times \frac{|b-3|}{\sqrt{1-r^2}} \times \frac{SdLnX}{SdLnY}_{\#}$$

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The calculated *t* with table t with n-2 degrees of freedom is compared. If calculated *t* was smaller than table t, it is isometric growth and if calculated *t* was greater than table t, so the growth will be an allometric growth.The relationship between catch per unit effort (y/f) and effort (f) with Schaefer linear equation was obtained:

$$y/f = a + bf(f \leq -\frac{a}{b})$$

Figure 1. Sampling stations in Zayandehrud dam, Isfahan, Iran

Also, Fox model was calculated. In this model, the relationship (y/f) with f is not linear in normal condition. However, if the logarithm values of (y/f) was used in relation, it would be converted to a linear equation.

$$y/f = \exp(c + df)$$

The sustainable catch (fMSY) and the MSY in Schaefer model are calculated as follows (Sparre and Venema 1998):

$$fMSY = -0.5 \times \frac{a}{b}$$

$$MSY = -0.25 \times \frac{a^2}{b}$$

The sustainable catch (fMSY) and the MSY in Fox model are calculated as follows (Sparre and Venema 1998):

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$$fMSY = -\frac{1}{d}$$

$$MSY = -\left(\frac{1}{d}\right) \times \exp(c - 1)$$

In order to analyze the effects of the fishing on a specific age category of fish stocks, virtual population analysis (VPA) model using FiSat software version 2 was applied. The statistical data analysis using SPSS software Version 16 and Excel 2013 were performed.

RESULTS AND DISCUSSION

In total, 617 fish with a total weight of 1109.5 kg belong to carp fish were taken. Caught carp fishes by fishermen were included: common carp (*Cyprinus carpio*), silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Hypophthalmichthys nobilis*), grass carp (*Ctenopharyngodon idella*), and mesopotamian barb (*Capoeta damascina)*, respectively. Also, crucian carp (*Carassius carassius*) was caught that has no economic value. In terms of the total catch of fish species composition, silver carp and common carp with 35% and 48% had the highest catch composition. Also in terms of comparable weight percent, silver carp with 52%, common carp with 38%, and bighead carp with 10% were three dominant carp species in Zayandehrud dam. Silver carp with 4 kg and common carp with 3 kg using the net with mesh size of 120 mm, Common carp with 1.5 to 2 kg weight using the net with mesh size of 80 mm and common carp with the lower weight of 500 gr using the net with mesh size of 70 mm were caught.

Statistics of released carp in Zayandehrud dam over 10 years showed that the rate of fish releasing due to the lack of credit have fallen by about a quarter in recent years (Iran Fisheries Organization 2014). The combination of released carps showed that common carp and silver carp have bigger portion than grass carp in the dam environment. According to the Department of Fisheries Isfahan (2014), 376000 fish larvae were released in the water resources annually that 180000 fish larvae were belonged to Zayandehrud dam (Table 2). Although the number of fishing effort has increased and the amount of catch per unit effort (CPUE) was greatly reduced in recent years compared to previous years and fell by half.

Due to the natural feeding at the entrance to the lake, most dispersal of fish particularly native fish were observed in shallow areas of the lake. According to annual statistics of Department of Fisheries Isfahan (2014), amounts of aquatic productions in inland waters sources were 815 tons in 2104 in Isfahan which most amounts were belonging to Zayandehrud dam with 500 tons (about 60%). Since carp fish species are not endemic in the lake, their larvae have been released by Fisheries Organization in the dam annually, which accordingly, common carp with (30%), grass carp with (5%), bighead with (5%) and silver carp with (60%) were released in Zayandehrud dam. But bighead carp due to lack of the fish larvae releasing has declined in recent years.

According to biometry process of caught fish, data analysis was performed on the carp fishes, and in examines of length and weight relationship, fishes are following of isometric growth model that reflects the consistent growth in length and weight of fish which indicates the status of the river dam ecosystem is almost appropriate (Figure 2). In examining the relationship between lengths and age of breeding carp, annual fish length growth follows the

Table 2. Release, effort and catch per unit effort statistics of fish in Zayandehrud dam, Isfahan, Iran

Year	Common carp (Per thousand)	Silver carp (Per thousand)	Grass carp (Per thousand)	Effort	Catch per unit effort
2005	100	25	125	200	3
2006	90	20	110	220	2.86
2007	90	20	110	250	2.6
2008	156	30	190	250	2.46
2009	70	20	100	320	2.13
2010	95	20	110	350	1.86
2011	28	5	25	324	1.85
2012	35	15	100	317	1.58
2013	32	7	39	317	1.58
2014	24	6	30	317	1.58

Table 1. The total number of caught fish in the sampling stations in Zayandehrud dam, Isfahan, Iran

Season	Total	Common carp	Silver carp	Big head carp	Grass carp	Crucian carp	Mesopotamian barb
Autumn	483	235	41	-	-	0	207
Winter	134	57	46	12	1	4	14

Table 3. Comparison of catch in gill nets with a height of 6 meters and 12 meters in 20 to 30 meters water depth in Zayandehrud dam, Isfahan, Iran

Species	Catch depth (m)	Common carp	Silver carp	Big head carp	Mesopotamian barb	Total (cm)
Number		12	6	1	7	26
Weight (g)	12-15	1800-2000	6500-9000	11200	4500	115000
Height (cm)		45-52	70-75	97	35	-
Number		16	50	3	8	77
Weight (g)	5-10	10700	203850	5300	2980	319130
Height (cm)		45-48	60-75	88-106	37	-

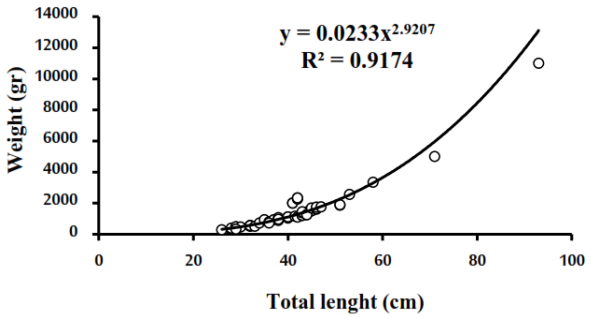

Figure 2. Length-weight relationship of common carp in Zayandehrud dam, Isfahan, Iran

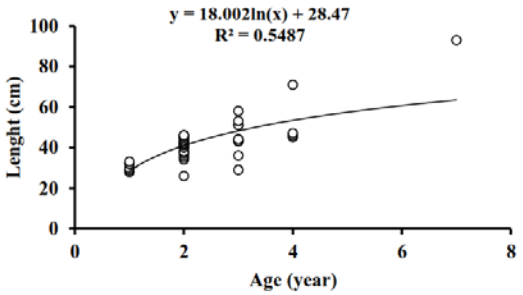

Figure 3. Age-length relationship of common carp in Zayandehrud dam, Isfahan, Iran

Table 4. Common carp growth conditions in behind of Zayandehrud dam, Isfahan, Iran

Age (year)	Average length (cm)	Average weight (g)	Biomass (ton)
1	30.5±5.2	473.8±17.51	12.41
2	40.88±6.45	1359.7±47.48	72.01
3	45±7.35	1565.7±65.7	10.99
4	51±5.75	2362±106.3	15.16
5	57.44±8.8	3202.5±160.12	3.31
6	60.73±7.6	3767.4±184.82	5.92
7	93±13.4	11000±495.62	6.16

Table 5. Silver carp growth conditions in behind of Zayandehrud dam, Isfahan, Iran

Age (year)	Average length (cm)	Average weight (g)	Biomass (ton)
1	30.5±4.27	513.27±20.01	16.39
2	39.92±6.78	1046.1±46.78	24.37
3	65.43±14.39	3311.43±215.24	20.76
4	78.1±16.46	5845±321.47	43.43
5	96.25±18.4	12200±951.6	18.03

natural logarithm model. In other words, the growth rate is reduced from the third year that shows the maturity happens at this age in carps (Figure 3).

In the study on some biometric and dynamics parameters of common carp, it was found that growth of fishes in the ecosystem is acceptable. Based on virtual population analysis (VPA), fishing mortalities at ages 3 and 4 years were in higher amounts than the other ages that according to used mesh size, it would seem logical. According to the obtained data from Zayandehrud dam, the biomass of common carp from 1 to 7 years was variable between 6.16 to 12.14 tons, which most biomass was related to fishes with the age of 2 years, amounts of 72.01 tons and an average weight of 1359.7 g (approximately 60%). Also, the lowest biomass was observed at the age of 5 years with amounts of 3.31 tons (2%) with an average weight of 3202.2 g (Table 4). Also abundance of common carp was variable at the age of 2 years with average weight of 1359.8 g in compared with silver carp at the ages of 3 to 5 years and from the weight of 3311.4 to 12200 g which the highest abundance was obtained at the age of 4 years with the average weight of 5845 g (Table 5).

In consider of some biometric and dynamic parameters of silver carp, it was found that such as common carp, the growth of silver carp is acceptable in Zayandehrud dam, because after four years, the fish has reached more than 5 kg in the dam environment. Due to very low mortality values obtained from carps, data has also been used for silver carp (Table 5).

In winter, due to low temperature and deactivation of feeding, carps live in winter dormancy period and have less mobility in the water body (Estoki 2000; Abdolmaleki 2004). As a result, the catches declined and population estimates are lower than the catch rates in spring, summer and autumn that can be obtained. In winter, silver carp and common carp catch conditions are more favorable than

endemic fish in Zayandehrud dam environment. In the overall, with regard to natural mortality (M) of 0.1 and 0.2, amounts of harvestable biomass for endemic fishes and natural reproduction of breeding carps (about half forecast based on estimated annual released fish for carp) were about 407 and 440 tons in Zayandehrud dam (Table 6).

Based on Schaefer and Fox models, these values were 623 and 609 tons respectively. Highest amounts of Schaefer and Fox model estimation were due to higher fishing on released fishes in previous years which actually lead prediction to higher levels of harvesting (Table 7). However, due to the great reduction in the release of fish larvae in recent years, it seems that logical harvesting is between 440 to 500 tons.

In the study of caught common carps in the autumn season, it was observed that the fishes were in the range of 22-93 cm which highest length ranges of caught fishes

Table 6. Estimates of harvestable quantities of fish in Zayandehrud dam, Isfahan, Iran, in 2015

Fish	Biomass (Natural mortality = 0.2)	Biomass (Natural mortality = 0.1)
Common carp	126	139.2
Silver carp	123	135.9
Grass carp	35	35
Endemic fishes	60	60
Natural reproduction	63	69.6
Total	407	439.8

Table 7. Estimates of harvestable quantities of fish based on Schaefer and Fox models in Zayandehrud dam, Isfahan, Iran

Fish	Schaefer (ton)	Fox (ton)
Amount of harvestable catch	622.9	608.6
Fishing effort	252.1	227.2

Table 8. Catchweight range and caught species in Zayandehrud dam, Isfahan, Iran in study period

Net mesh size	Catch weight range (g)	Caught species	No	Catch total weight (kg)
40	200-400	Mesopotamian barb	195	64
60	300-950	Common carp, Mesopotamian barb	106	48.9
70	950-1500	Common carp	90	101.66
80	1500-3000	Common carp	43	81.4
90	3000-4500	Common carp, Silver carp	38	156.49
100	4500-8500	Common carp, Silver carp	8	40
150	8500-11000	Common carp, Silver carp	3	33

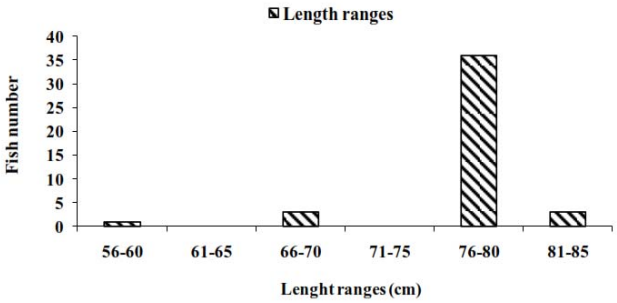

Figure 4. Absolute abundance of silver carp in different length classes in Zayandehrud dam, Isfahan, Iran, in autumn

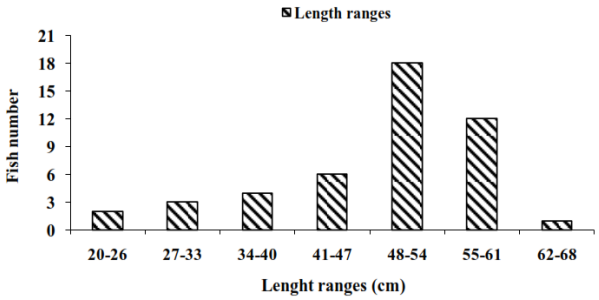

Figure 5. Absolute abundance of silver carp in different length classes in Zayandehrud dam, Isfahan, Iran, in winter

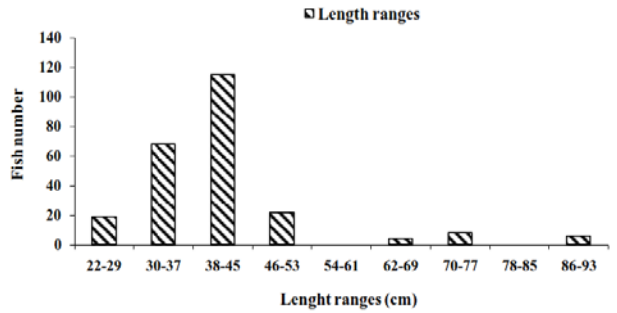

Figure 6. Absolute abundance of common carp in different length classes in Zayandehrud dam, Isfahan, Iran, in autumn

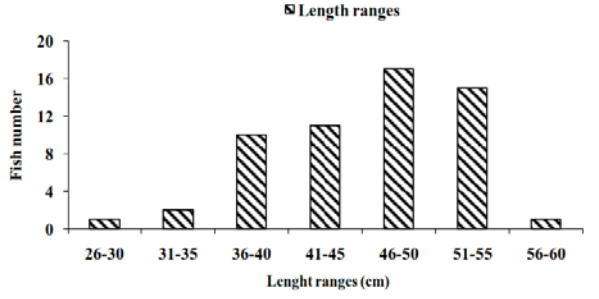

Figure 7. Absolute abundance of common carp in different length classes in Zayandehrud dam, Isfahan, Iran, in winter

were in the range of 38-45 cm (Figure 4).While in winter, it was observed that fish were in the range of 26-60 cm and most frequencies of length classes were in the range of 46-50 cm (Figure 5). Also according to caught silver carps in the autumn season, it was observed that the fishes were in the range of 56-86 cm which more of caught fishes were in the range of 76-80 cm (Figure 6). Moreover, in the winter season, it was observed that fish were in the range of 20-68 cm and most frequencies of length classes were in the range of 48-54 cm (Figure 7). According to biological studies in Mahabad dam, the average length of caught common carp in total catch was 36.94 cm with a minimum length of 16 cm and a maximum of 67 cm (Abdolmaleki 1999). Among non-native species, common carp biomass was highest that seems to be similar to the terms of Shadeganwetland in Khuzestan (Hashemi and Eskandari 2009).

In addition, in the study of caught mesopotamian barb, it was observed that caught fishes were in the range of 18-35 cm which most abundance of mesopotamian barb belonged to the class of 20-21 cm. Mesopotamian barb condition in the lake is dependent on the natural reproduction and is not related to the releasing of fish larvae by Department of Fisheries Isfahan (2014). The exact amount of caught fish is not available in previous years. According to Abbasi et al. (2007) in Siah Darvishan River in Anzali, maturity age is 3 to 4 years for mesopotamian barb. Since the age of the caught fish was between 2-3 years, it seems that overfishing is done in the lake. Therefore, use of fishing nets with small mesh should be managed. According to the research that was carried out on Hanna Lake dam, mesopotamian barb (*Capoeta damascina*) as endemic species was dominant (Estoki 2000). Also in Abodlmaleki study on fish composition in Maku dam, a mesopotamian barb with 95% of total fishes was dominant species (Abdolmaleki 2000).

The results of this study showed that the combination of sampling, estimation of fishing and harvesting of some species are highly dependent on the releasing process of fish larvae in behind the dam. If the annual releasing decline, it will be a severe impact on the lake production, especially carp fish (silver carp, bighead carp and grass carp). But other fishes such as mesopotamian barb (endemic fish) and common carp (with natural reproduction in spring) are affected by fishing. Therefore, it is essential to manage fishing activities for the sustainable product in fishing seasons. Large lakes due to their size, in the absence of appropriate conservation and management, cannot be expected to have a favorable and stable advantage (Bernacsek 1984). In this context, comprehensive and systematic data collection on the fluctuations of fish stocks and fishing effort in Zayandehrud dam is very important.

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