Monofilament gill net and trammel net selectivity for the silver crucian carp (*Carassius gibelio* Bloch, 1782) in the Eğirdir Lake, Isparta-Turkey

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Received: April 2013 Accepted: April 2014

Abstract

The aim of this study was to determine the selectivity of monofilament gillnets with different mesh size for silver crucian carp in Eğirdir Lake. In this study, it was investigated that the selectivity of monofilament gillnets with nominal mesh size (stretched) with 32, 40, 50, 60, 70, 80, 90 mm and trammel nets with 100, 110, 120, 130, 140, 150 mm for catching of silver crucian carp. Fieldwork was carried out in two different station of Eğirdir Lake, between January-2010 and December-2010 with a three-month period and a total of 4 catching operations. (Share Each Length class Catch Total) (SELECT) method was used to determine the selectivity parameters. In the experiments 1562 silver crucian carp species in ranges of the length between 7.9 cm-37.0 cm were caught. As a result of calculations made according to the bi-modal model which gave the lowest deviation, for gill nets optimum length (cm) was found as 8.77, 10.96, 13.70, 16.44, 19.18, 21.92, 24.66 for 32, 40, 50, 60, 70, 80, 90 mm mesh size; for trammel nets optimum length (cm) was found to be 24.90, 27.39, 29.88, 32.37, 34.86 for 100, 110, 120, 130 and 140 mm mesh size monofilament trammel nets, respectively.

Keywords: Monofilament, Selectivity, SELECT method, *Carassius gibelio*

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Introduction

Silver crucian carp (*Carassius gibelio* Bloch, 1782) which have normal distribution areas in Korea, Northeast China, Russia (Zou *et al*., 2000) and in the Asian countries, but recently it is encountered (Baran and Ongan, 1988) in Gala Lake in Turkey for the first time, this species showed a rapid spread in a short time. Firstly it was seen in all Thrace region and then in many regions of Turkey, including the eastern places (Polat *et al*., 2011). Despite it is an invasive species, it has become an important source of income for our fishermen with the recent emerging market in the Middle East. Production quantities of catching this fish is not clear in species level, it is due to the fact that it is included in carp or other fish groups by Turkey Statistical Institute. According to the TUIK data, while the total production of other fish groups were 12 tons/year in Isparta Province in 2009 and 2010, it was 1106,5 tons/year in 2011, it is thought that this increase results from dense catching of silver crucian carp.

To ensure the sustainability of our aquaculture resources by means of healthy production is possible with proper operation of our stocks. It is known for many years that gill nets are more selective than other catching tools. Enhancing selectivity of catching tools has a great importance to ensure continuity of stocks and to obtain maximum continuous production (Sümer *et al*., 2007).

The basic principle in gill nets; based on the capture of actively moving fish to the mesh from the end of nose, behind the gill cover or trapped in the front of the dorsal fin (Pope *et al*., 1975; Sümer *et al*., 2010).

Turkey doesn’t have any legal restriction on catching of silver crucian carp. Recently the silver crucian carp being a target species in many lakes led us to the fall of mesh size to 60-70 mm especially in lakes that have no control over mesh size. This is an extremely adverse catching pressure on majority of the species.

Although it is an invasive species, catching of it directly affect other species, knowing selectivity of nets that have different mesh sizes has gained importance in recent years.

In our study, we tried to determine selectivity characteristics of gill nets and trammel nets that are made of monofilament material and have 32, 40, 50, 60, 70, 80, 90 mm mesh size gill nets and 100, 110, 120, 130, 140, 150 mm mesh size trammel nets in selectivity of crucian carp.

Materials and methods

The study was carried out in two different station of Eğirdir Lake, in the period of January-2010 to December-2010 with a three-month interval period and a total of 4 catching operation (Fig. 1).

Monofilament gill nets with 32, 40, 50, 60, 70, 80, 90 mm mesh size (stretched) and trammel nets with 100, 110, 120, 130, 140, 150 mm mesh size (stretched) nets, all had 0.18 mm rope thickness and a depth of 50 mesh as used vertically. The catching was done with renegade method and by adding the nets together (setting nets at sunset and gathering them in early morning). The caught fish were classified according to the nets and total lengths determined with 1 mm precision of measurement board, and weights were measured with 1g precision of digital scale.

The SELECT method was used to determine selectivity (Millar, 1992; Millar and Holst, 1997; Millar and Fryer, 1999). This method assumes that the number of fish with a length of *l* caught with a mesh size of *j* has a nl_j poisson distribution, and is defined by the following equation (Acarlı *et al*., 2013):

$$nl_j \approx \text{Pois}\,(p_j(l)\,\lambda_l r_j\,(l)) \quad (1)$$

Where λ_l is abundance of fish of size *l* caught in net; $p_j\ (l)$ is relative fishing intensity (relative abundance of fish of size *l* that j mesh size can catch). Poisson distribution of the number of fish of size *l* caught by fishing gear with *J* mesh size is defined as $p_j\ (l)\lambda_l.\ r_j(l)$ is the selectivity curve for *j* mesh size (Acarlı *et al*., 2013).

$$\sum_l \sum_j \{n_l \log[p_j\ \lambda_l\ r_j\ (l)] - p_j\ \lambda_l\ r_j\ (l)\} \quad (2)$$

The data obtained from field studies were analyzed by PASGEAR version 2.4 (Kolding, 1999) computer software. The software calculates parameters of 5 different models (normal location, normal scale, log-normal, gamma, and bi-modal) based on SELECT (Millar, 1992; Millar and Holst, 1997; Millar and Fryer, 1999) method.

Standard deviation of all models was evaluated when selecting the most suitable model in calculations. The model with greater standard deviation shows that the model in question is not appropriate for the obtained data (Akamca *et al*., 2010). The most suitable model was chosen taking into account the lowest standard deviation value. Model equations of SELECT method are as follows:

Normal Location:

$$\exp\left(-\frac{(L-k.m_j)^2}{2\sigma^2}\right) \quad (3)$$

Normal Scale:

$$\exp\left(-\frac{(L-k_1.m_j)^2}{2k_2^2.m_j^2}\right) \quad (4)$$

Log-Normal:

$$\frac{1}{L}\exp\left(\mu+\log\left(\frac{m_j}{m_1}\right)-\frac{\sigma^2}{2}-\frac{\left(\log(L)-\mu-\log\left(\frac{m_j}{m_1}\right)\right)^2}{2\sigma^2}\right) \quad (5)$$

Gamma:

$$\left(\frac{L}{(\alpha-1).k.m_j}\right)^{\alpha-1}\exp\left(\alpha-1-\frac{L}{k.m_j}\right) \quad (6)$$

Bi-modal:

$$\exp\left(-\frac{(L-k_1.m_j)^2}{2k_2^2.m_j^2}\right)+c.\exp\left(-\frac{(L-k_3.m_j)^2}{2k_4^2.m_j^2}\right) \quad (7)$$

Kolmogorov-Simonov test was used to determine differences between size frequency distributions of fish caught by nets that have varying mesh size (Siegel and Castellan, 1988; Karakulak and Erk, 2008, Acarlı *et al*., 2013).

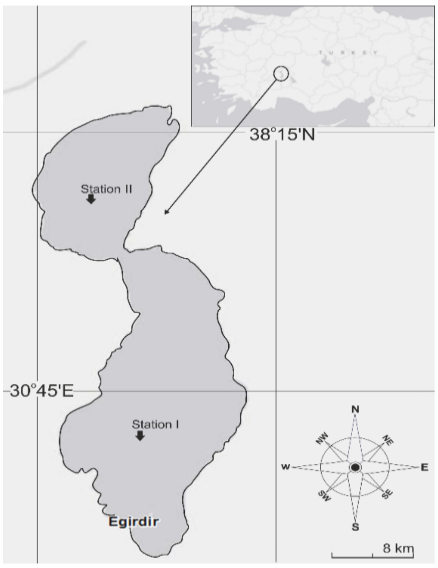

Figure 1: Study area and sampling stations inLake Eğirdir.

Results

As a result of 4 catching operations, a total of 1562 silver crucian carp fish with a length range of 7.9-37.0 cm were caught. The distribution of caught fish according to the nets is shown in Table 1. Trammel net with 150 mm mesh size didn't catch fish. The average fish length (±SD) for32, 40, 50, 60, 70, 80, 90 mm mesh size gillnets were determined as 9.7±0.08, 11.6±0.09, 14.1±0.11, 16.8±0.21, 20.0±0.14, 21.5±0.13, and 22.8±0.14; and for 100, 110, 120, 130, 140 mm mesh size trammel nets were determined as 25.4±0.13, 26.7±0.17, 28.2±0.23, 29.6±0.40, 32.4±1.30 cm respectively (Table 1). The total length–frequency distribution for fish caught using different mesh size is shown in Fig. 2

(for gill nets) and in Fig. 3 (for trammel nets).

Table 1: Number and average length of fish caught by trial nets.

Net Type	Length of mesh size (mm)	Number of fish caught (N)	Number of fish caught (%)	Average length ±SE (cm)	Minimum Length (cm)	Maximum Length (cm)
Gill Nets	32	84	5.40	9.7±0.08	7.9	12.2
	40	150	9.60	11.6±0.09	9.1	16.8
	50	94	6.00	14.1±0.11	12.1	19.4
	60	98	6.30	16.8±0.21	14.2	25.6
	70	161	10.30	20.0±0.14	16.4	25.7
	80	213	13.60	21.5±0.13	13.5	31.4
	90	205	13.10	22.8±0.14	18.2	29.5
Trammel Nets	100	238	15.20	25.4±0.13	18.7	31.6
	110	147	9.40	26.7±0.17	19.8	35.9
	120	101	6.50	28.2±0.23	21.4	33.4
	130	66	4.20	29.6±0.40	15.6	37.0
	140	5	0.30	32.4±1.30	27.9	35.4

With the PASGEAR computer software, parameters of normal location, normal scale, log-normal, gamma and bi-modal models is calculated separately and the results is shown in Table 2. As a result of comparing model deviations it was determined that the most appropriate model was bi-modal for both gill nets and trammel nets (Table 2).

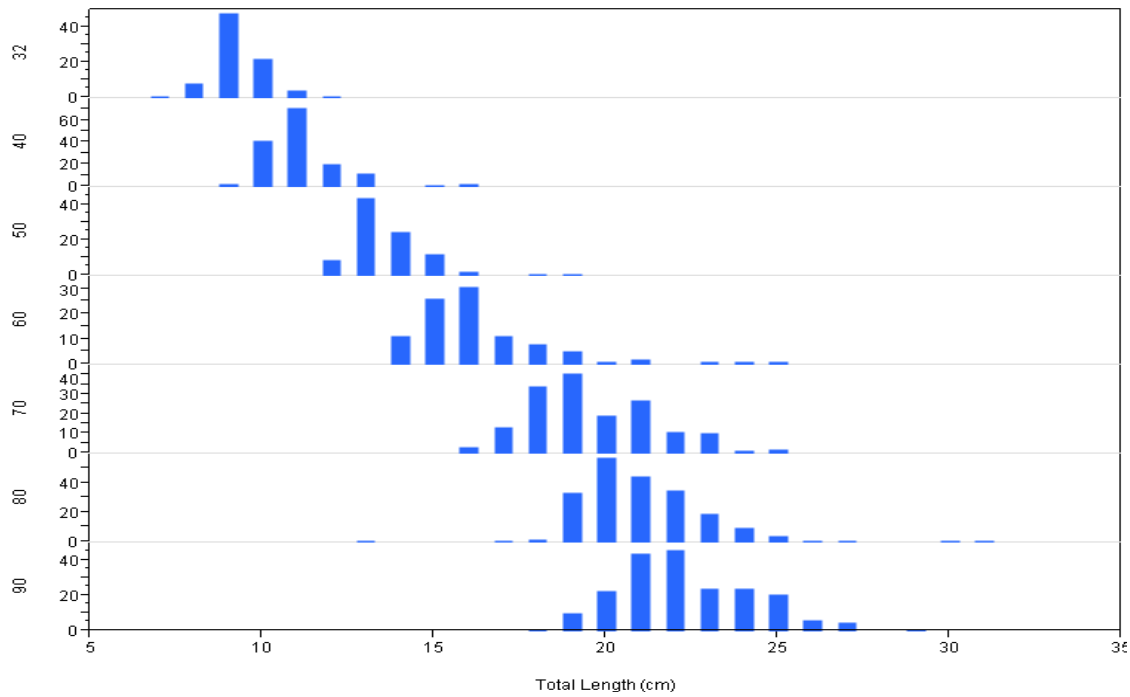

Figure 2:Total length frequency distribution of fish caught using different mesh sizes for gill net.

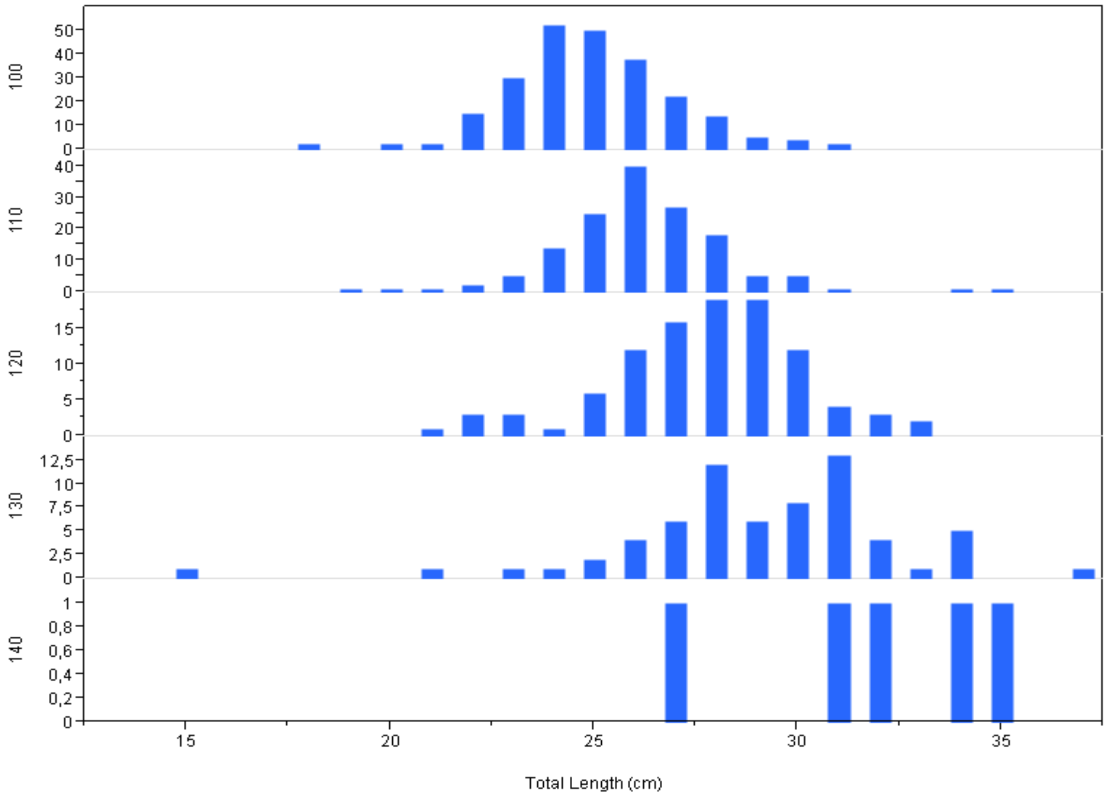

Figure 3: Total length frequency distribution of fish caught using different mesh sizes for trammel net.

Table 2: Selectivity parameter values of silver crucian carp.

Model	**Net Group**	**Parameters**	**Modal Deviance**	**p-value**	**Degree of Freedom (d. f.)**
Normal location		(k, σ)=(0.269, 2.023)	290.471	0.000000	64
Normal scale		(k1, k2)=(0.280, 0.031)	257.864	0.000000	64
Lognormal	Gill Nets	(μ_1, σ)=(2.187, 0.110)	218.523	0.000000	64
Gamma		(k, α)=(0.003,81.860)	228.403	0.000000	64
Bi-modal*		(k_1, k_2, k_3, k_4, w) (0.274, 0.024, 0.315, 0.046, 0.113)	**190.718**	**0.000000**	**61**
Normal location		(k, σ)=(0.257, 3.159)	103.200	0.000329	59
Normal scale		(k1, k2)=(0.259, 0.025)	88.811	0.007288	59
Lognormal	Trammel Nets	(μ_1, σ)=(3.266, 0.112)	106.538	0.000149	59
Gamma		(k, α)=(0.003, 88.336)	98.881	0.000883	59
Bi-modal*		(k_1, k_2, k_3, k_4, w) (0.249, 0.015, 0.281, 0.039, 0.514)	**54.830**	**0.519230**	**56**

*Parameters of appropriate model

Selectivity curves were drafted by PASGEAR software according to the obtained parameters showed in Figs. 4 and 5. The optimum length and distribution values calculated in regard to the bi-model for each net groups that have different mesh size are given in Table 3.

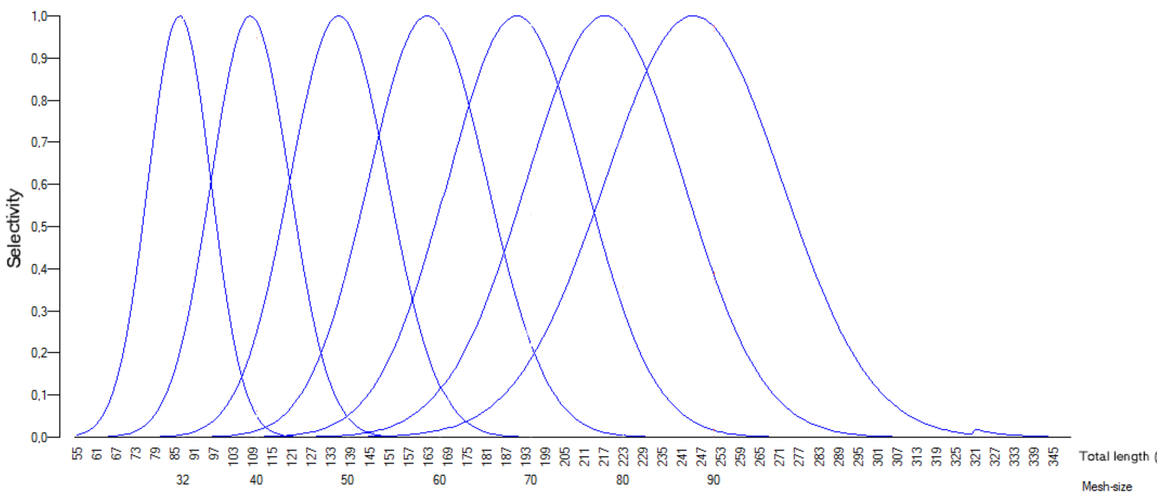

Figure 4: Selectivity curves of gill nets.

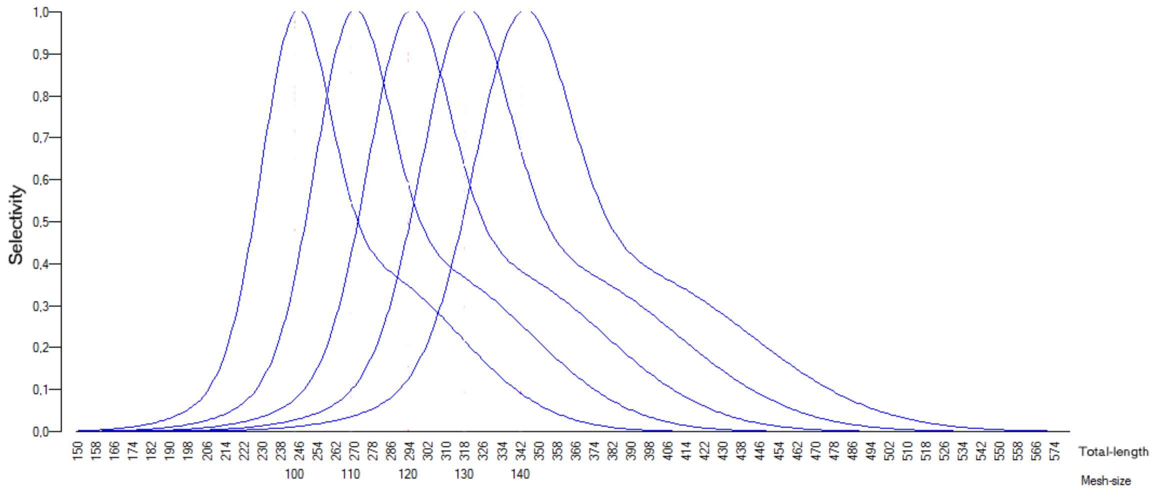

Figure 5: Selectivity curves of trammel nets.

Table 3: Optimum length and distribution values of silver crucian carp according to the bi-modal model.

Mesh size	Net type	Modal length (cm)	Spread value (cm)
32	Gill Nets	8.77	0.77
40		10.96	0.96
50		13.70	1.20
60		16.44	1.44
70		19.18	1.68
80		21.92	1.92
90		24.66	2.16
100	Trammel Nets	24.90	1.50
110		27.39	1.65
120		29.88	1.80
130		32.37	1.95
140		34.86	2.10

According to the results of Kolmogorov-Smirnov test that applied to query differences of length frequency distributions of fish caught by nets, differences were significant in all of the nets (Tables 4, 5).

Table 4: Results of the Kolmogorov- Smirnov test used to compare length frequency distribution of fish caught by gill nets.

Net 1		Net 2		Kolmogorov-Simirnov Test		
Mesh size	N	Mesh size	N	D max	Critical values (α=0.05)	Decision
32	84	40	150	0.6656	0.1845	H_0 Reject
32	84	50	94	0.9881	0.2022	H_0 Reject
32	84	60	98	1.0000	0.2004	H_0 Reject
32	84	70	161	1.0000	0.1823	H_0 Reject
32	84	80	213	1.0000	0.1748	H_0 Reject
32	84	90	205	1.0000	0.1757	H_0 Reject
40	150	50	94	0.8082	0.1766	H_0 Reject
40	150	60	98	0.9800	0.1745	H_0 Reject
40	150	70	161	0.9867	0.1534	H_0 Reject
40	150	80	213	0.9954	0.1444	H_0 Reject
40	150	90	205	1.0000	0.1455	H_0 Reject
50	94	60	98	0.7229	0.1944	H_0 Reject
50	94	70	161	0.9605	0.1757	H_0 Reject
50	94	80	213	0.9741	0.1679	H_0 Reject
50	94	90	205	0.9846	0.1689	H_0 Reject
60	98	70	161	0.7092	0.1734	H_0 Reject
60	98	80	213	0.8693	0.1655	H_0 Reject
60	98	90	205	0.8861	0.1665	H_0 Reject
70	161	80	213	0.3901	0.1415	H_0 Reject
70	161	90	205	0.5206	0.1426	H_0 Reject
80	213	90	205	0.2888	0.1324	H_0 Reject

H_o: There are no significant differences in the length frequency distributions.

Table 5: Result of the Kolmogorov- Smirnov test used to compare length frequency distributions of fish caught by trammel nets.

Net 1		Net 2		Kolmogorov- Smirnov Test		
Mesh Size	N	Mesh Size	N	D max	Critical Values (α=0.05)	Decision
100	238	110	147	0.3184	0.1415	H_0 Reject
100	238	120	101	0.5549	0.1593	H_0 Reject
100	238	130	66	0.6664	0.1849	H_0 Reject
100	238	140	5	0.8805	0.4618	H_0 Reject
110	147	120	101	0.3891	0.1738	H_0 Reject
110	147	130	66	0.5605	0.1975	H_0 Reject
110	147	140	5	0.8685	0.4670	H_0 Reject
120	101	130	66	0.3109	0.2115	H_0 Reject
120	101	130	66	0.7998	0.4731	H_0 Reject
130	66	140	5	0.6111	0.4833	H_0 Reject

H_o: There are no significant differences in the length frequency distributions.

Discussion

In trials, the highest catch obtained from 100 mm mesh size net and the least obtained from 150 mm. This finding is in agreement with the study carried out by Çınar and Kuşat (2010) who compared efficiency of monofilament and multifilament nets with 50, 55, 60 and 65 mm mesh size (bar length) in catching silver crucian carp in Eğirdir Lake. These authors reported that the highest efficiency that they obtained was from 50 mm and the least was obtained from 65 mm mesh size nets. In accordance with these findings it can be said that the most efficient monofilament net is 100 mm mesh size in the catching of silver crucian carp, there is no ban for catching fish with it.

The lengths of fish caught in field studies ranged between 7.9-37.0 cm and the reason for this is the use of many different mesh sizes. Balık (1999) reported that; flexibility and bending of the net rope affect selectivity and generally as flexibility increases there is an expansion in the average length of fish and selectivity range of the fish caught. Nets used in the study which are made of monofilament material, may cause differences between lengths distributions of fish caught, as reported by Balık (1999).

According to the results of Kolmogorov-Smirnov tests, it is determined that there are significant differences between length distributions of the all nets. In the direction of this findings, it can be said that the selectivity of monofilament nets were considerably good in the catching of silver crucian carp.

It is assumed that bi-modal model is the best proper model in cases of fish caught and entangled in mesh (compression, wrapping, pouch), and wider range of length distribution (Holt, 1963; Hovgard, 1996; Akamca *et al*., 2010). Also in this study, it is determined that the best model was bi-modal model that calculates most proper selectivity with the obtained data.

The literature review in order to compare the lengths of optimal catch showed that there are no specific study on *C. gibelio*. According to Lorenzoni *et al*. (2010) optimum catch lengths were 37.94 and 43.36 for 35 and 40 mm mesh size (bar length) nets in *C. auratus*. Yalçın (2006) and Holt (1963) who studied net selectivity in carps, reported optimum catch length for *Cyprinus carpio* as 27.4, 30.4, 33.4 and 36.5 cm for 45, 50, 55 and 60 mm mesh size (bar length) and as 30.0, 33.4, 36.7, 43.4 cm respectively for common carp, respectively. Balık (1999) and Holt (1963) reported optimum catch length for carp in the Beyşehir Lake to be 18.07, 20.66, 39.33 and 42.35 cm for 35, 40, 65 and 70 mm mesh sizes (bar length), respectively. It has been comprehended that the optimum catch lengths reported by Lorenzoni *et al*. (2010) is higher than those of this study. The reason these variations comes from the differences in species, habitat and selectivity method used in the two studies. Turkey doesn't have any restriction related to catching silver crucian carp. City Departments of Food, Agriculture and Livestock have the responsibility in bringing restrictions to fishing in the area with different applications. In some Provinces, while the use of gill nets smaller than 140 mm mesh size is banned in order to conserve carp stocks, there isn't any restriction due to lack of length limitation for silver crucian carp catch. Restrictions in carp catch make no significant catch pressure on silver crucian carp. In this study it was determined that the nets with 140 mm and more mesh sizes were inefficient in catching silver crucian carp. The continuous process of fishing management in this manner, considering the reproductive characteristics this would cause and increasing trend in the populations of silver crucian carp and decreasing trend in the populations of carp. Presence of no restrictions in silver crucian carp catch would cause a significant catch pressure on the silver crucian carp and prevent excessive proliferation of it. However the drop in the mesh size to 70-80 mm causes extremely catching pressure on other species. Pertain to the future of this species which is known for approximately 25 years in freshwaters of Turkey, there should be clear national decision and individual practices should be eradicated. Removal of this invasive species from freshwaters of Turkey seems unlikely in short term. Catching strategies should be developed and implemented to prevent excessive proliferation of silver crucian carp as well as protect other species in the environment. To serve this, Turkey Statistical Institute should give the production amount of silver crucian carp on species bases. As a result, this study is very important in terms of net selectivity and creating scientific data to fisheries management authorities.

Acknowledgements

This study was financed by the Republic of Turkey, Ministry of Food, Agriculture and Livestock, General Directorate of Agricultural Research and Policy. Furthermore, I would like to thank the Mediterranean Fisheries Research Production and Education Institute.

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