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Trammel Net Selectivity of Common Carp (*Cyprinus carpio* L., 1758) in Manyas Lake, Turkey

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A B S T R A C T

The aim of this study was determine the selectivity properties of trammel net which have 100, 110, 120, 130 and 140 mm mesh size for *Cyprinus carpio* in Manyas Lake. Fieldwork was carried out in two different stations of Manyas Lake, in a monthly period from April 2007 to March 2008 and with a total of 24 catching trials. The SELECT method was used to determine the selectivity parameters. In the experiments, 208 *C. carpio* with length ranges between 28.4-65.4 cm were caught. According to the *Lognormal* model, the optimum total lengths were determined as 39.05, 42.95, 46.85 and 50.76 cm for 100, 110, 120, 130 and 140 mm mesh sizes respectively. As a result, in terms of the length at first maturity and legal status, the mesh size of nets used for *C. carpio* catching in Manyas Lake should not less than 120 mm.

Keywords: Trammel net, selectivity, SELECT method, *Cyprinus carpio*

A R T I C L E I N F O

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Manyas Gölü'ndeki (Balıkesir/Türkiye) Sazan Balığı için (*Cyprinus carpio* L., 1758) Fanyalı Uzatma Ağı Seçiciliği

Öz: Bu çalışmanın amacı 100, 110, 120, 130 ve 140 mm göz açıklığındaki fanyalı uzatma ağlarının Manyas Gölü'nde sazan balığı avcılığındaki seçicilik özelliklerini belirlemektir. Saha çalışması Nisan 2007 ile Mart 2008 arasında aylık olarak toplam 24 avcılık operasyonu ile yürütülmüştür. Seçicilik parametrelerinin belirlenmesinde SELECT metot kullanılmıştır. Deneme süresince 28.4-65.4 cm boy aralığında 208 adet *C. carpio* yakalanmıştır. Lognormal modele göre yapılan hesaplamalarda 100, 110, 120, 130 ve 140 mm göz açıklığındaki ağlar için optimum yakalama boyu aynı sırayla 39.05, 42.95, 46.85 ve 50.76 cm olarak belirlenmiştir. Sonuç olarak ilk üreme boyu ve yasal statüye göre Manyas Gölü'nde *C. carpio* avcılığında 120 mm göz açıklığının altındaki ağlar kullanılmamalıdır.

Anahtar kelimeler: Fanyalı ağ, seçicilik, SELECT metot, *Cyprinus carpio*

Introduction

Cyprinus carpio is very important species for Turkey's inland fisheries. It is located many inland water in Turkey both natural and depend on introduce operation. *C. carpio* is main target species for inland fishermen due to the commercial value. Therefore catch pressure on that species has increased and this has caused decreasing the production depend on fisheries year to year. The annual production was 15631 tons in 1996, but that was 8276 tons in 2013 with the decrease of total production to 47% from 1996 to 2013 (TUIK 2014). The overfishing, invasive species (especially *Carassius gibelio*), pollution and habitat destruction have negative effect on production. The contribute to Turkey economy of *C. carpio* was ₺36996402.00 ($19461547.00) in 2013 (TUIK 2014).

In the catching of *C. carpio* which is bulkier than the other species of inland water, trammel net is used by the fishermen. According to fishermen the reason of this is that *C. carpio* often break away from gilnets by plucking the net rope. In support of this idea Çubuk (2000) reported that the trammel nets were more productive than gillnets for *C. carpio* cathing in Beyşehir Lake.

The trammel net design enables catching fish by two different processes; (a) gilling and entangling, like conventional gill nets, and (b) trapping large fish in the bags of the inner netting (FAO 2000; Karakulak and Erk 2008). It is very easy to put into practice the results of selectivity studies that on

trammel nets. From this perspective the results of selectivity studies are very valuable that will use in legal regulations for fish stock sustainability.

The first reproduction length of *C. carpio* reported as (with a male and female ranking as a fork length) 26.2 cm, 31.4 cm in Çıldır Lake (Yerli and Zengin 1998); 29 cm, 39 cm in Nazik Lake (Şen 2001) and 18 cm and 31 cm in Karasu Stream (Şen and Elp 2009).

In this study, the selectivity property of trammel nets that have 100, 110, 120, 130 and 140 mm mesh sizes were determined for fishing of *C. carpio*.

Materials and Methods

The study was conducted at two different stations in Manyas Lake (Figure 1). Fish samples were caught monthly, between April 2007 and March 2008. In catching trials, inner panel of the trammel nets that are made of monofilament material with 100, 110, 120, 130 and 140 mm stretched mesh sizes which have 0.20 mm rope thickness with *E*=0.50 hanging ratio were used. Outer panel mesh size of the trammel nets with 500 mm (for 100, 110, 120, 130 mm inner panel) and 600 mm (for 140 mm inner panel). The depths of all nets were 50 meshes and which have 100 m long inner panel.

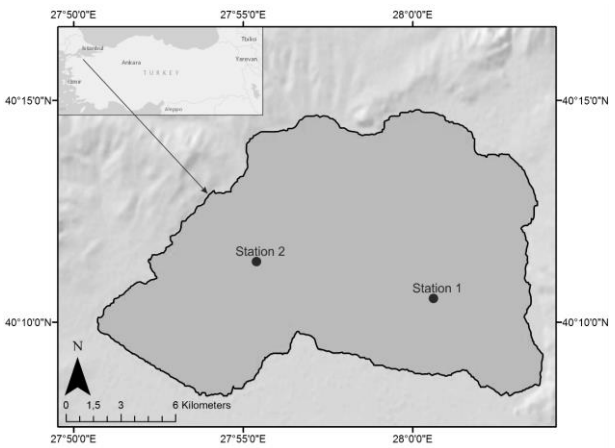

Figure 1. Study area and sample station.

All nets were set in the afternoon and lifted the following morning. Caught fish were classified according to the nets and total lengths determined by 1 mm precision measurement board and weights with 1g precision digital scale.

The SELECT (Share Each Length-class's Catch Total) method was used to determine the selectivity ((Millar 1992; Millar and Holst 1997; Millar and Fryer 1999). This method assumes that the number of fish of length *l* caught with a mesh size with j size has a *nlj* Poisson distribution, and is defined by the following equation (Acarlı et al. 2013):

$$n_{lj} \approx n_{lj} \approx \mathrm{Pois}(p_j \lambda_l r_j(l))$$

where λl is the abundance of fish of size l caught in net; *pj* (l) is relative fishing intensity (the relative abundance of fish of size l that j mesh size can catch). The Poisson distribution of the number of fish of size l caught by fishing gear with J mesh size is defined as $pj\ (l)\lambda l.rj(l)$ is the selectivity curve for j mesh size (Acarlı et al. 2013).

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

The data obtained from field studies were analyzed by R code developed by Millar (2011). The length selectivity of each mesh size was described by four different models (normal location, normal scale, gamma and lognormal) of the 'Share Each Length's Catch Total' (SELECT) method (Millar and Fryer 1999).

Model deviance of all models evaluated when selecting the most suitable model from calculations. The model has greater standard deviation shows that the model in question is not appropriate to the obtained data (Park et al. 2004; Akamca et al. 2010). The most suitable model was chosen taking into account the lowest deviance value. The SELECT method's equations as follows:

Normal Location:

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

Normal Scale:

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

Log-Normal:

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

Gamma:

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

Kolmogorov-Smirnov (*K-S*) test was used to determine differences between size frequency distributions of fish caught by nets that have varying mesh size (Siegel and Castellan 1989; Karakulak and Erk 2008; Acarlı et al. 2013).

Results

After the 24 catching operations, a total of 208 common carp that have lengths range of 28.4-65.4 cm were caught. While the most productive net was 120 mm mesh size with 65.4% catching capacity of total catch, 110 mm mesh size net was unproductive with 2.9% catching of total catch. The distribution of caught fish according to the nets was showed in Table 1. Average length (±*SD*) for 100, 110, 120, 130 and 140 mm mesh size gill nets were determined as 37.2±5.0, 40.1±4.3, 50.3±7.2, 47.9±2.2, 44.6±6.0 respectively (Table 1). The total length-frequency distribution for fish caught using different mesh size are shown in Figure 2.

By comparing the deviances of four model of SELECT method, lognormal model with the lowest deviance 453.26 gave the best fit (Table 2). The selectivity curves that were drafted by lognormal parameters via R Code software that have been showed in Figure 3. The optimum length and spread values calculated in regard to the lognormal for each net panels that have different mesh size are given in Table 3. The modal lengths and spread value estimated for this model are presented in Table 3.

Table 1. Catch composition data of trial nets.

Length of mesh size (mm)	Number of fish caught (N)	Number of fish caught (%)	Average length ±*SD* (cm)	Minimum length (cm)	Maximum length (cm)
100	14	6.7	37.2±5.0	28.4	43.5
110	6	2.9	40.1±4.3	34.7	44.0
120	136	65.4	50.3±7.2	35.3	65.4
130	38	18.3	47.9±2.2	42.3	51.7
140	14	6.7	44.6±6.0	32.2	52.7

Table 2. Selectivity parameter values of *C. carpio*.

Model	Parameters	Model Deviance	Degree of Freedom (d.f.)
Normal location	(k, σ)=(0.4026, 10.10)	459.40	126
Normal scale	($k1$, $k2$)=(0.4034, 0.0063)	455.64	126
Lognormal	***(μ_1, σ)=(3.7046, 0.1997)***	***453.26***	***126***
Gamma	(k, α)=(0.0155, 26.3397)	453.52	126

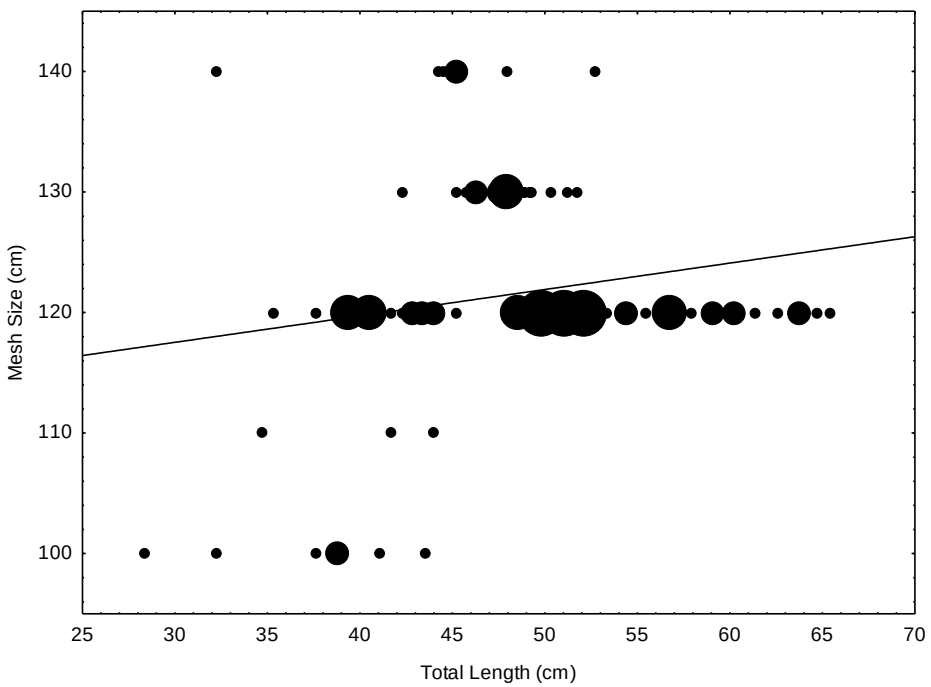

Figure 2. Catch size frequency distributions for the *C. carpio*.

According to the results of *K-S* test that applied for query difference of length frequency distributions of fish caught by nets, differences were founded in all nets (Table 4).

Table 3. Optimum length and spread values of *C. carpio* according to the Lognormal.

Mesh size	Model Length (cm)	Spread Value (cm)
100	39.05	8.36
110	42.95	9.20
120	46.85	10.03
130	50.76	10.87
140	54.66	11.71

Table 4. Result of the *K-S* test used to compare length frequency distributions of catch.

Net 1	Net 2	*K-S* Test	Decision	Net 1	Net 2	*K-S* Test	Decision
100	110	0.6000>0.5631	H_0 Reject	110	130	0.9524>0.5936	H_0 Reject
100	120	0.7571>0.3812	H_0 Reject	110	140	0.6667>0.6411	H_0 Reject
100	130	0.9524>0.4197	H_0 Reject	120	130	0.3354>0.2401	H_0 Reject
100	140	0.8889>0.4846	H_0 Reject	120	140	0.3725>0.3411	H_0 Reject
110	120	0.7286>0.5670	H_0 Reject	130	140	0.3977>0.3891	H_0 Reject

H_0: There are no significant differences in the length frequency distributions (α=0.05; k=1.36).

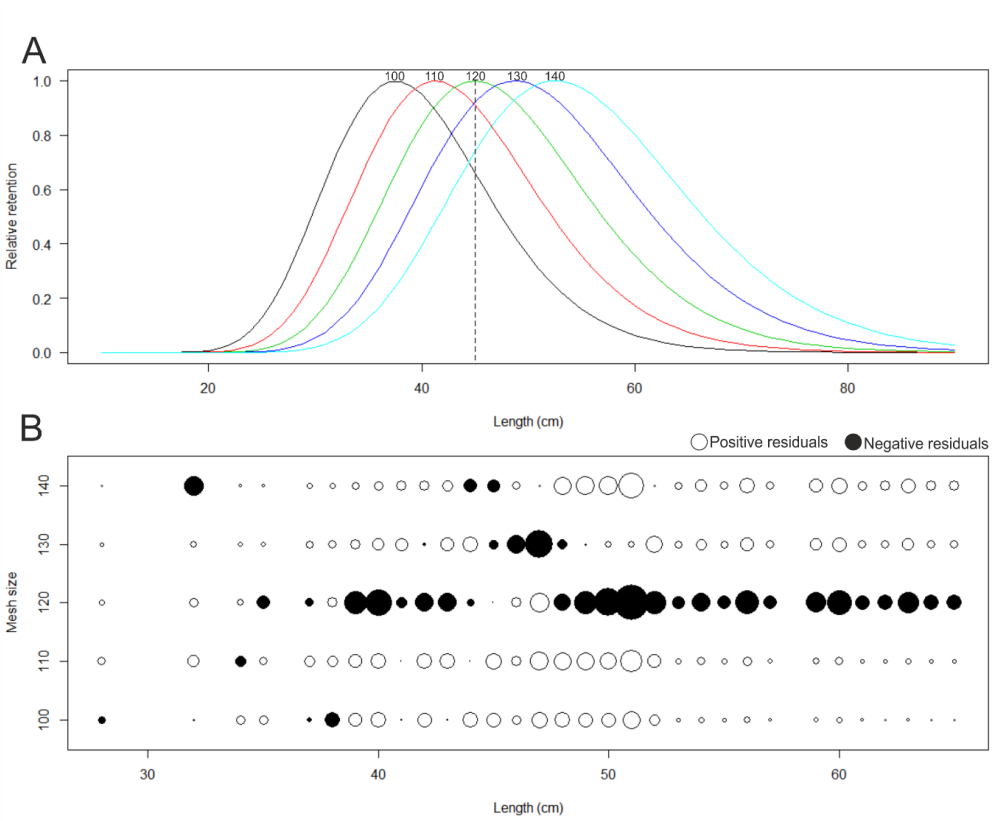

Figure 3. Selectivity curves (A) and deviance residual plots (B) of trammel net for the *C. carpio*.

Discussion

The determination of selectivity is needed to ensure the management of commercial gill net fishing, protection of small fish and prevention death and escape of them. Therefore, it is necessary to determine the optimum mesh size for obtaining maximum continuous product (Hamley 1975; Sümer et al. 2010).

The one of main principle for sustainable of fish population is that at least one maturating in their natural location. Hence minimum landing size of fish must be longer than first maturity length. The main purpose of this study is determination the trammel nets that catch the *C. carpio* that have above first maturity length. For this purpose many selectivity studies have been carried out by different researcher used different method on different localities. The comparisons of the selectivity studies of *C. carpio* between present and previous research results are showed in Table 5.

Table 5. The comparisons of the selectivity studies of *C. carpio* between present and previous research results.

Author	Location	Method	*N*	Mesh Size (mm)	Material	Modal Length (cm)
(Özyurt and Avşar 2005)	Seyhan Dam Lake	Holt (1963)	294	28	Monofilament Gillnets	17.55
				32		20.06
				40		24.44
				45		27.50
(Balık 1999)	Beyşehir Lake	Holt (1963)	352	70[a]	Monofilament Gillnets	18.07
				80[a]		20.66
				130[a]		39.33
				140[a]		42.35
(Yalçın 2006)	Different Anatolian Reservoirs	Holt (1963)	1139	45[b]	- Gillnets	27.4
				50[b]		30.4
				55[b]		33.4
				60[b]		36.5
(Carol and García-Berthou 2007)	Different Reservoirs in Catalonia (NE Spain)	SELECT	116	29[a]	Monofilament Gillnets	10.89
				38[a]		14.27
				51[a]		19.15
				64[a]		24.03
				84.5[a]		31.73
				101.5[a]		38.12
				135.5[a]		50.89
				177.5[a]		66.66
				201.5[a]		75.67
				253[a]		95.01
Present study	Manyas Lake	SELECT	208	100[a]	Monofilament Trammel nets	39.05
				110[a]		42.95
				120[a]		46.85
				130[a]		50.76
				140[a]		54.66

[a]mesh size (stretched); [b]mesh size (bar length).

When analyzing the Table 5, there is significant differences between optimum catch length of similar mesh size. For instance, Balık (1999) reported that optimum length as 39.33 cm for 130 mm mesh size and that result is very smaller than 50.76 cm for same mesh size that reported by us. The reason of this is differences originated from selectivity method, locality and sampling period and technical differences of gillnet-trammel net. Despite that, the optimum length that reported as 38.12 cm for 101.5 mm net by Carol and García-Berthou (2007) with SELECT method is quite close to 39.05 cm that reported by us for similar net (100 mm) and method.

Balık (2008) reported that Holt (1963) method is one of the most commonly used methods for estimating gillnets selectivity, however this method is restrictive. Recently, the SELECT method has been used commonly this is a statistical "model that estimates gillnet selection curves from comparative gillnet catch and provides a cohesive approach to selectivity analyses. Balık and Çubuk (2001) reported that selectivity of gillnets can vary for each fish species and even for population of same species in different habitat therefore selectivity should be determine separately for each species which catching by this nets (Sümer et al. 2010).

Both consideration (Table 6) the first maturity that reported by Yerli and Zengin (1998), Şen (2001), Şen and Elp (2009) and legal status, the mesh sizes of trammel nets that used in catching of *C. carpio* in Manyas Lake shouldn't less than 120 mm.

Table 6. Determination criteria of fit mesh size for *C. carpio* by first maturity and legal status.

Author	Sex	*FL*	**SL=(FL-a)/b*			**TL=a+bSL*		
			r^2	*a*	*b*	r^2	*a*	*b*
			0.999	0.6881	1.0613	0.999	0.2635	1.1937
Yerli and Zengin (1998)	♂	26.2		24.0			29.0	
	♀	31.4		28.9			34.8	
Şen (2001)	♂	29		26.7			32.1	
	♀	39		36.1			**43.4**	
Şen and Elp (2009)	♂	18		16.3			19.7	
	♀	31		28.6			34.4	
MLS by Circular (2012/65)	♀+♂	-		-			40.0	

FL: Fork length; *SL*: Standard length; *TL*: Total length; *MLS*: Minimum landing size *by Gaygusuz et al. (2006).

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