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RESEARCH ARTICLE ARAŞTIRMA MAKALESİ

The effect of gillnet twine thickness on catching efficiency and selectivity for common carp (*Cyprinus carpio* Linnaeus, 1758) fishery in Marmara Lake

Uzatma ağlarında ip kalınlığının Marmara Gölü'ndeki sazan (*Cyprinus carpio* Linnaeus, 1758) avcılığında av verimi ve seçicilik üzerine etkisi

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Abstract: The effects of multifilament gillnet twine thickness on selectivity and catching efficiency for the common carp fishery were investigated in this study. Sampling was carried out with multifilament gillnets of two different twine thicknesses (with 210d/2 and 210d/3) on 140, 150, 160, 180, 200 mm mesh sizes between June 2015 and December 2016 in Marmara Lake, located in Western Turkey. Higher modal lengths and lower catch per unit effort (CPUE) values and lower sub-minimum landing size (MLS) individuals rate (excluding 180 and 200 mm mesh sizes) were obtained in the thick multifilament material (210d/3) with the same mesh size compared to thin material (210d/2). All mesh sizes in both twine thickness provided modal lengths above the MLS. However, the thin twine material had a higher nominal percentage of undersized fish (8%), greater than the 5% accepted limit for total catches when all mesh sizes are considered together. As a result, the modal lengths and spread values increased and the selectivity and catching efficiency decreased with the thicker twine material.

Keywords: *Cyprinus carpio*, twine thickness, selectivity, catching efficiency, gillnet, Marmara Lake

Öz: Bu çalışma ile sazan avcılığında kullanılan multifilament sade uzatma ağlarının ip kalınlığının, seçicilik ve av verimliliği üzerine etkileri araştırılmıştır. Denemeler, Türkiye'nin batısındaki Marmara Gölü'nde, 140, 150, 160, 180, 200 mm tam göz boyundaki multifilament sade uzatma ağları ile iki farklı ip kalınlığında (210d/2 ve 210d/3), Haziran 2015 ve Aralık 2016 tarihleri arasında gerçekleştirilmiştir. Kalın ipte (210d/3), aynı göz genişliğindeki ince ipe göre (210d/2) daha yüksek model boyları, daha düşük birim çabaya düşen av miktarı (CPUE) değerleri ve daha düşük oranda yasal yakalama boyu (YYB) altında balık (180 ve 200 mm tam göz boyları hariç) elde edilmiştir. Her iki ip kalınlığında tüm ağ göz genişliklerinde YYB üzerinde model boyları sağlanmıştır. Ancak, tüm ağ boyları birlikte değerlendirildiğinde ince ipte YYB altı balık oranı (%8), toplam av için kabul edilen yasal sınırın (%5) üzerinde çıkmıştır. Sonuç olarak, kalın iple model boyları ve yayılım değerleri artmış, seçicilik ve av verimi azalmıştır.

Anahtar kelimeler: *Cyprinus. carpio*, ip kalınlığı, seçicilik, av verimi, uzatma ağı, Marmara Gölü

INTRODUCTION

Common carp (*Cyprinus carpio* Linnaeus, 1758), is the second most caught freshwater fish in Turkey comprising 22% of catches, after Tarek (*Alburnus tarichi* Guldenstaedtii, 1814), an endemic carp species found only in Turkey which comprised 28% of catches between 2008 and 2019. However, there has been a 73% decrease in common carp catches from 11,600 t to 3,100 t in the last 12 years (from 2008 to 2019) (TUIK, 2020). This drastic decline in catches situation emphasizes the need and importance of sustainable freshwater fisheries management in Turkish waters. For sustainable fisheries management, fishing gear should ensure that immature fish are excluded from catches and that only the matured stock is targeted (Armstrong et al., 1990). Thus, studies determining the selectivities of fishing gear are of great importance in advising appropriate fisheries management control (Hamley 1975; Çetinkaya et al., 1995).

There are many factors affecting gillnet selectivity (Yüksel and Aydın, 2012). A limited number of selectivity studies have been conducted on several of these factors in common carp fishing in Turkey such as the effects of mesh size (Balık, 1999; Özyurt and Avşar, 2005; Yalçın, 2006; Cilbiz et al., 2015; Şen, 2016), the color of the material (Balık and Çubuk, 2001a), and hanging ratio (Dartay and Ateşşahin, 2017) on selectivity of the common carp in gillnets.

The gillnet twine thickness and the light condition in the water are considered the most important factors affecting selectivity and catching efficiency of common carp, as they cause the fish to notice the gill net and affect their catchability (Cui et al., 1991; Özdemir and Erdem, 2006). The twine thickness becomes more important in shallow lakes where light transmission is high. There are two studies on the effect of twine thickness on selectivity and efficiency in common carp fishery. In these studies, Aras (2015) studied the selectivity with multi-monofilament nets, and Balık and Çubuk (2004) compared the effect of monofilament and multifilament materials on efficiency. There have been no prior studies on the selectivity of multifilament nets in Turkey for common carp.

Thus, this study aims to determine the effects of twine thickness of multifilament material on selectivity and catching efficiency of gillnets for common carp fishing in Marmara Lake (Figure 1), which is a very shallow lake (approximately 3-4 m deep) located in Western Anatolia, Turkey, which is an important common carp habitat and fishing site. Additionally, the selectivity and catching efficiency of 180 and 200 mm mesh size multifilament gillnets were examined for the first time.

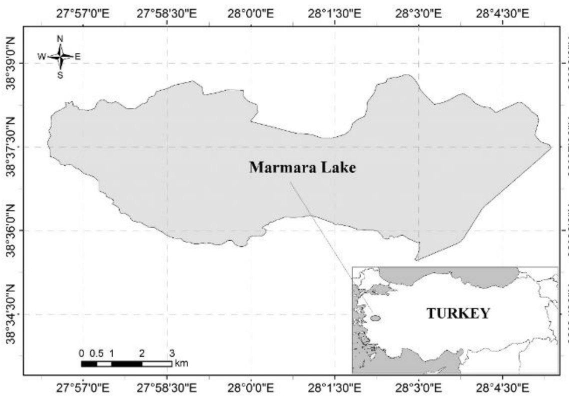

Figure 1. Study area (Marmara Lake)

MATERIAL AND METHODS

This study was carried out monthly between June 2015 and December 2016, excluding March until May (which are closed seasons for fishing), with the help of commercial fishers at different sites in Marmara Lake. In each operation, multifilament gillnets with the same characteristics as the ones used in commercial fisheries: thin twine thickness (210d/2) and thick twine thickness (210d/3), with 140, 150, 160, 180, 200 mm mesh sizes were used (Figure 2). As in commercial fishing, a passive fixed method was used to set the nets in the afternoon and retrieve them the following morning. The soak times averaged 16 hours.

After net retrieval, the caught fish were then sorted according to gillnet mesh size and twine thickness type, and then identified to species level according to Geldiay and Balık (2009). Total length was measured to the nearest 1 mm and weight was assigned to the nearest gram by a digital scale. The minimum, maximum and mean values of carp lengths and weights were calculated for each net group. The weight ratios of common carp below the minimum landing size (40 cm) were calculated for each gear type to determine the proportion of juveniles. The catch per unit effort (CPUE) was calculated as kg/1000 m using the following equation: $CPUE = \Sigma(Y/L)/n$

Y is the catch in weight (kg) of a given species in one operation, L is the length of nets standardized as 1000 m and n is the number of operation (Hyvärinen and Salojärvi, 1991; Balık and Çubuk, 2001b).

Indirect estimation using the SELECT method was used to determine selectivity (Millar, 1992 and 1995; Millar and Holst 1997; Millar and Fryer, 1999), where the expected catch proportions are fitted to the observed catch proportions using maximum likelihoods, under the assumption that catches fall under the Poisson distribution (Feller 1968; Millar and Fryer 1999).

The SELECT method is defined by the following equation;

$$\mathrm{n}_{lj} \approx \mathrm{Pois}\left(p_j \lambda_l r_j(l)\right) \quad \textbf{(1)}$$

where n_{lj} is the number of fish of length l caught in mesh size j, p_j is the fishing intensity, λ_l reflects the abundance of the length class l, $r_j(l)$ denotes the retention probability of length l fish in the j'th mesh size.

The Poisson distribution of the number of fish of size l caught by fishing gear with j mesh size is defined as $p_j(l)\lambda_l r_j(l)$ the selectivity curve for j mesh size. The log-likelihood of n_{lj} is:

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

The selectivity parameters of nets were estimated using GILLNET software (Constat 1998) which is based on the comparison of fish caught with different nets, calculated by the parameters of five different models: Normal location, normal scale, log-normal, gamma, and bi-modal. These models are from Millar (1992); Millar and Holst (1997); and Millar and Fryer (1999):

Normal location: $$\exp\left(-\frac{(l-k.m_j)^2}{2\sigma^2}\right) \quad \textbf{(3)}$$

Normal scale: $$\exp\left(-\frac{(l-k_1.m_j)^2}{2k_2^2.m_j^2}\right) \quad \textbf{(4)}$$

Log-normal: $$\frac{\mathrm{m_j}}{l.\mathrm{m_1}}\exp\left(\mu-\frac{\sigma^2}{2}-\frac{\left(\log(l)-\mu-\log\left(\frac{m_j}{m_1}\right)\right)^2}{2\sigma^2}\right) \quad \textbf{(5)}$$

Gamma: $$\left(\frac{l}{(\alpha-1).k.m_j}\right)^{\alpha-1}\exp\left(\alpha-1-\frac{l}{k.m_j}\right) \quad \textbf{(6)}$$

Bi-modal: $$\exp\left(-\frac{(l-k_1.m_j)^2}{2k_2^2.m_j^2}\right)+c.\exp\left(-\frac{(l-k_3.m_j)^2}{2k_4^2.m_j^2}\right) \quad \textbf{(7)}$$

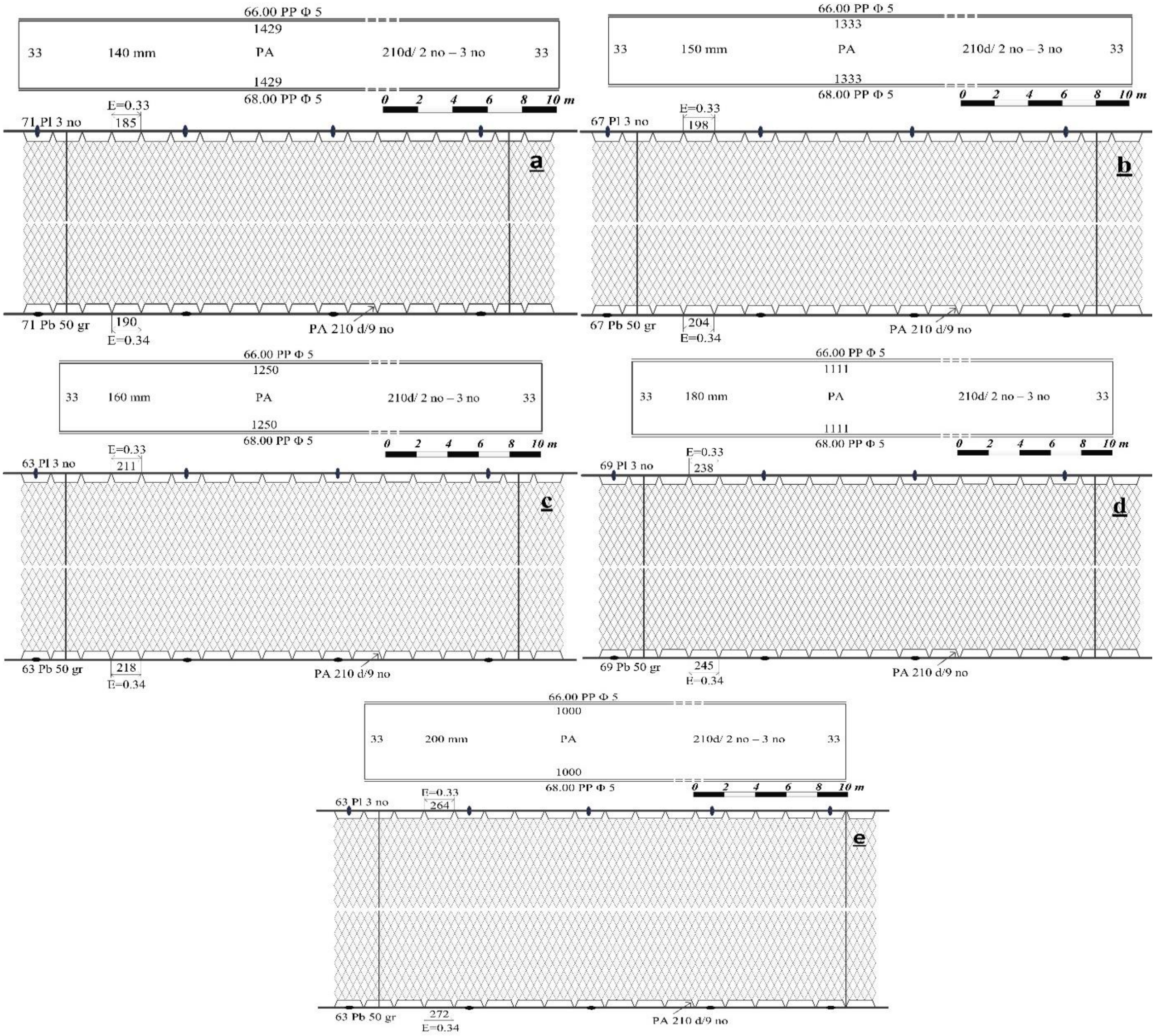

Figure 2. Scaled (top) and detailed (below) technical plans of gillnets of 210d/2 and 210d/3 (a:140 mm, b:150 mm, c:160 mm, d:180 mm, e:200 mm)

The best-suited model was then chosen according to the standard deviance values of the models, and the selectivity curves were plotted according to the parameters of the model with the lowest deviance value (Millar and Holst, 1997; Park et al., 2004). According to this model, optimum modal lengths and spread values were determined and deviance residuals were plotted using the deviance values.

The IBM SPSS (Version 22) program was used in statistical evaluations. The Kolmogorov–Smirnov (K-S) test was used to compare the catch size-frequency distributions. The normality of data was tested (Shapiro-Wilk test) and, whenever necessary, the log-transformation log (x+1) was used. To compare the mean length and CPUE, either the t-test or Mann-Whitney U test was used, depending on if the data were normally distributed. All collected data were pooled together for each mesh size and gear type before the K-S, t-test and Mann-Whitney U test were performed.

RESULTS

From a total of 48 catch operations, a total of 440 fish from four species totaling 970.7 kg were caught. The target species, common carp was the most captured species in both twine thicknesses net groups (390 n; 89% of the number of total fish, and 942.5 kg; 97% of the total catch weight). Also, 40 individuals of pike perch (*Stizostedion lucioperca* Linnaeus, 1758), six individuals of gibel carp (*Carassius gibelio* Bloch, 1782), four individuals of mirror carp (*Cyprinus carpio* L., 1758 var. *specularis)* were caught. In addition to fish, ten crayfish (*Astacus leptodactylus* Eschscholtz, 1823) were caught. According to the net groups, the common carp distributions based on twine thicknesses are presented in Table 1.

Table 1. Total length and weight values of common carp in the 210d/2 and 210d/3 (n: number of fish caught, min: minimum, max: maximum, se: standard error)

	Mesh size (mm)	n	Total weight (kg)	Total length (cm)			Weight (kg)		
				Min.	Max.	Mean±SE	Min.	Max.	Mean±SE
Thin 210d/2	140	81	114.1	23	66.5	44.9 ± 0.66	0.17	4.7	1.41 ± 0.06
	150	85	130	32.2	81.5	45.9 ± 0.75	0.5	7.8	1.53 ± 0.11
	160	27	84.3	32	82	58.6 ± 2.55	0.51	8.1	3.25 ± 0.41
	180	22	116.6	27.5	88.2	67.8 ± 3.5	0.36	10.1	5.3 ± 0.59
	200	10	82.4	66	105.2	80.1 ± 4.08	3.85	18.2	8.24 ± 1.46
	Total	225	527.4						
Thick 210d/3	140	61	107.5	32	91	48.1 ± 1.03	0.61	10.7	1.92 ± 0.17
	150	53	100.1	31	93	48.4 ± 1.31	0.5	11.6	1.89 ± 0.22
	160	26	80.3	44.2	90.1	57.9 ± 2.60	1.3	10.7	3.09 ± 0.53
	180	16	63.5	28	81.1	61.9 ± 4.26	0.88	7.1	3.97 ± 0.56
	200	9	63.7	67.7	82.5	76.7 ± 1.79	5.85	10.3	7.08 ± 0.45
	Total	165	415.1						

A total of 225 individuals (527.4 kg) were caught in the thin 210d/2 gillnets, and 165 individuals (415.1 kg) were caught from the thicker 210d/3 gillnets. Mean lengths and weights for 140, 150, 160, 180 and 200 mm mesh sizes in the 210d/2 and 210d/3 are presented in Table 1. According to increasing mesh size; mean lengths and weights of the carp increased linearly for both twine thicknesses of gillnets, except for the 140 and 150 mm mesh sizes of the 210d/3.

Length-frequency distributions of common carp are provided in Figure 3, and are combined here for 210d/2 and 210d/3. For both net types, the length distribution ranged from 23-105.2 cm (Figure 3).

The ratios of common carp landed below the MLS (40 cm) for 140, 150, 160, 180, 200 mm mesh sizes (210d/2) were 12.3, 8.2, 3.7, 9.1 and 0%, respectively (Figure 4). For 210d/3, the percentages of undersized common carp were 6.6, 5.7, 0, 12.5 and 0%, respectively. When all mesh sizes are considered together, twenty of the fish (8%) caught in the 210d/2 were under the MLS size and nine carp (4.5%) caught in the 210d/3 were below the MLS size as presented in Figure 4.

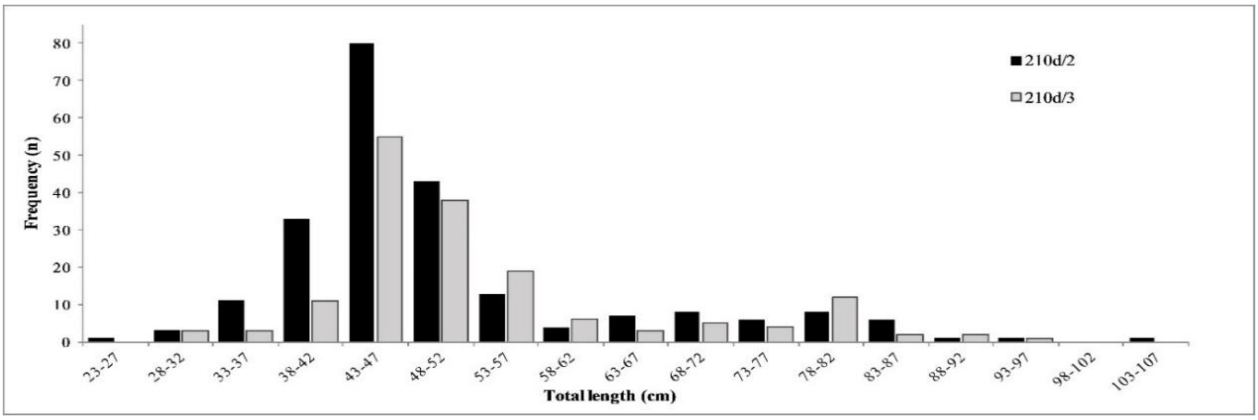

Figure 3. Comparison of total length-frequency distributions of carp caught in 210d/2 (black bars) and 210d/3 (grey bars)

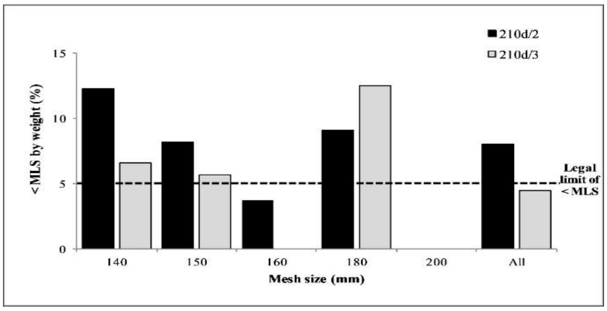

Figure 4. Comparison of the ratios of undersized common carp caught in 210d/2 (black bars) and 210d/3 (grey bars)

The highest CPUE values were determined as 13.27 kg/1000 m in 150 mm mesh size for 210d/2 and as 10.97 kg/1000 m in 140 mm mesh size for 210d/3. The CPUE value decreased with increasing mesh size above 140 mm in the 210d/3 (Table 2).

A comparison of mean total lengths (L), length frequencies and CPUE values of common carp in 210d/2 and 210d/3 are provided in Table 2. Although there were no statistical difference, proportionally higher CPUE values were obtained at 210d/2 in all mesh sizes (Table 2). When all mesh sizes are considered together, the CPUE value of the thinner 210d/2 gillnets was 1.27 times more efficient than the thicker 210d/3 gillnets.

Table 2. Comparison of mean total lengths (L), length frequencies and catch per unit effort (CPUE) values of common carp in gillnets with 2 different twine thicknesses (210d/2 and 210d/3)

Mesh size (mm)	L (mean±se) 210d/2	210d/3	Mann-Whitney U test	t-test	K-S test	CPUE (kg/1000 m) 210d/2	210d/3	Ratio (210d/2: 210d/3)	Mann-Whitney U test
140	44.93±0.66	48.11±1.03	P<0.05 (P=0.004)		P<0.05 (P=0.010)	11.66	10.97	1.06	P>0.05 (P=0.198)
150	45.9±0.75	48.42±1.31	P<0.05 (P=0.032)		P>0.05 (P=0.097)	13.27	10.22	1.30	P>0.05 (P=0.443)
160	58.59±2.55	57.93±2.6	P>0.05 (P=0.742)		P>0.05 (P=0.607)	8.6	8.2	1.05	P>0.05 (P=0.816)
180	67.8±3.5	61.86±4.26		t=1.084 df=36 P>0.05 (P=0.286)	P>0.05 (P=0.496)	11.91	6.48	1.84	P>0.05 (P=0.075)
200	80.11±4.08	76.76±1.79		t=0.752 df=12.287 P>0.05 (P=0.466)	P>0.05 (P=0.435)	8.41	6.51	1.29	P>0.05 (P=0.974)

The mean lengths were higher in 210d/3 with 140 and 150 mm mesh sizes ($p<0.05$). A significant difference also was found between length frequencies for only 140 mm according to the Kolmogorov-Smirnov test ($p<0.05$). Alternatively, the 210d/2 showed higher mean lengths in the 160, 180 and 200 mm mesh sizes, although these were not significant (Table 2).

The selectivity parameters for common carp calculated in the SELECT method are presented in Table 3. By comparing the deviances of the five models in the SELECT method, the normal location model due to its lowest deviance value was the most appropriate model for both sets of twine thicknesses.

Table 3. Selectivity parameter values for 210d/2 and 210d/3 (α, k, μ, σ, k_1, k_2, k_3, k_4: Selectivity constants of models)

Twine thicknesses	Model	Equal fishing powers parameters	Model Deviance	p-value	Fishing power α mesh-size parameters	Model Deviance	p-value	Degree of Freedom (df)
210d/2	**Normal Location**	**(k; σ) (4.0373,10.3334)**	**186.45**	**0.6385**	**(k; σ) (4.1308, 10.3988)**	**185.86**	**0.6500**	**194**
	Normal Scale	(k_1; k_2) (4.1162, 0.5713)	189.83	0.5712	(k_1; k_2) (4.1956, 0.5640)	189.97	0.5684	194
	Gamma	(k; α) (0.1008, 40.5836)	188.21	0.6037	(k; α) (0.1008, 41.5836)	188.21	0.6037	194
	Log Normal	(μ; σ) (4.0371, 0.1692)	190.87	0.5501	(μ; σ) (4.0657, 0.1692)	190.97	0.5501	194
	Bi-modal	No Fit			No Fit			
210d/3	**Normal Location**	**(k; σ) (4.2120, 12.2172)**	**165.23**	**0.9024**	**(k; σ) (4.3374, 12.3421)**	**165.25**	**0.9023**	**190**
	Normal Scale	(k_1; k_2) (4.3691, 0.6804)	170.59	0.8406	(k_1; k_2) (4.4743, 0.6691)	170.82	0,838	190
	Gamma	(k; α) (0.1360, 32.0356)	165.86	0.8963	(k; α) (0.1360, 33.0356)	165.86	0.8963	190
	Log Normal	(μ; σ) (4.1029, 0.1930)	166.65	0.8880	(μ; σ) (4.1402, 0.1930)	166.54	0.8880	190
	Bi-modal	No Fit			No Fit			

Table 4. Modal lengths and spread values for 210d/2 and 210d/3

Twine	Mesh size	Modal length	Spread value
210d/2	140	56.59	10.33
	150	60.56	
	160	64.59	
	180	72.67	
	200	80.74	
210d/3	140	58.97	12.22
	150	63.18	
	160	67.39	
	180	75.82	
	200	84.24	

The modal lengths and spread values calculated according to the normal location model for 140, 150, 160, 180, and 200 mm mesh sizes are presented in Table 4.

The modal lengths increased with mesh size in both twine thicknesses nets. The fitted selectivity curves with the corresponding deviance residual plots are presented in Figure 5. 210d/3 has higher values in modal lengths of the same mesh sizes compared to 201d/2. In addition, 210d/3 were higher in spread value (12.22 cm) compared with 210d/2 (10.33 cm) (Table 4 and Figure 5)

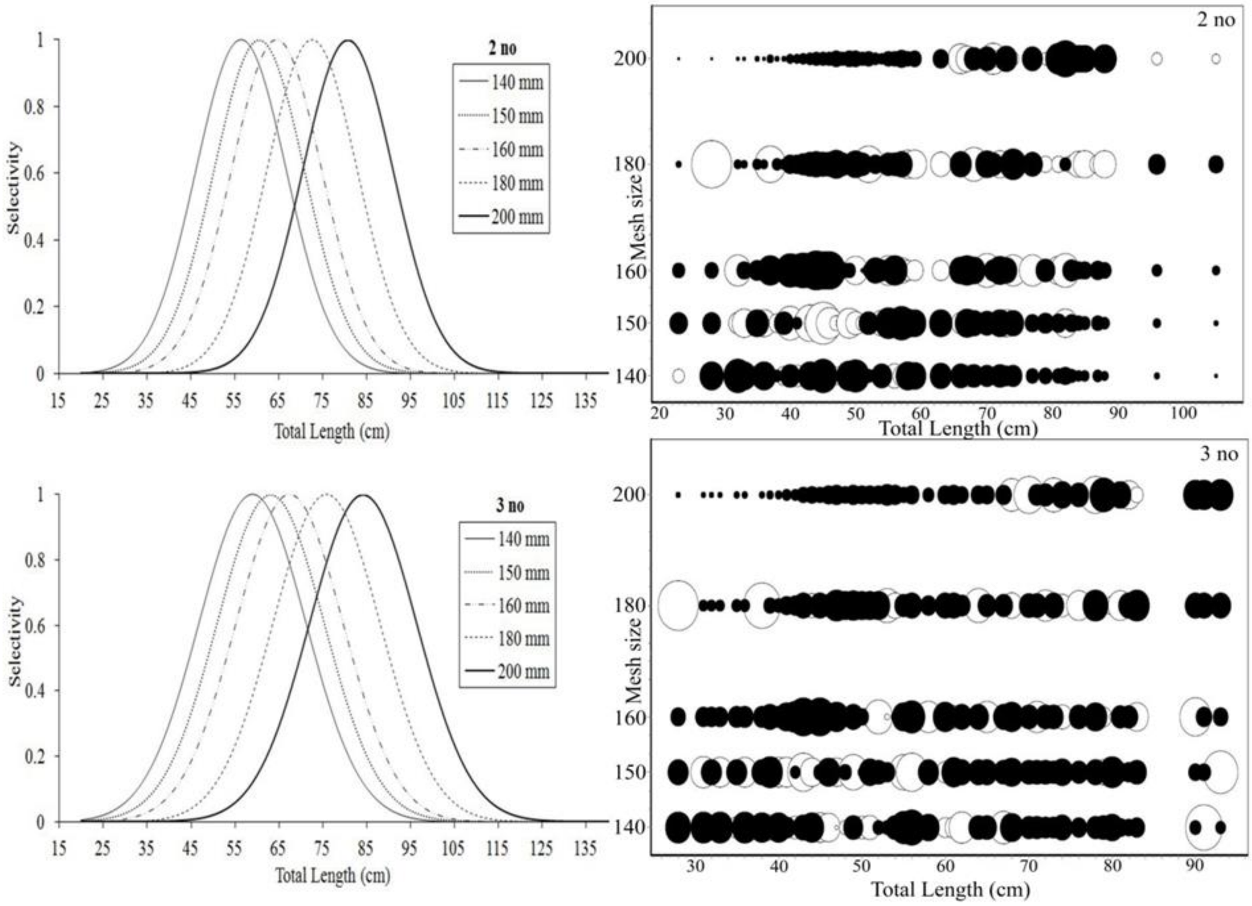

Figure 5. Selectivity curves of 210d/2 and 210d/3, and deviance residual plots (● positive residual, ○ negative residual)

DISCUSSION

Higher modal lengths were found using the thicker multifilament material (210d/3) compared to thinner material (210d/2) in this study. Similarly, Aras (2015) reported that thicker twine material had higher modal lengths than thin twine material for multi-monofilament gillnets in carp fishing. Different results were reported on the effect of twine thickness for other fish species. For example, Hansen (1974), Holst et al. (2002), and Ayaz et al. (2011) found that thinner twines have higher modal lengths than thicker ones, while Yokota et al. (2001) found thicker twine materials to have higher modal lengths than thinner materials. On the other hand, according to Hovgard (1996), Gray et al. (2005), and Turunen (1996) there was no difference found for modal lengths relating to net twine thickness. This variety of results may be resultant of different gear materials (mono vs. multifilament), or from different target species (Ayaz et al., 2011). In terms of selectivity in this study, it was determined that thicker multifilament material (210d/3) were less selective due to their higher spread values.

Regarding other selectivity studies on carp, generally other materials such as monofilament and multi monofilament, and mesh sizes less than 140 mm were considered (Table 5). This study demonstrated model lengths of overlapping mesh size (140 mm) on both thin and thick nets higher than in another study by Aydın et al. (2016), from the same lake, which may be attributable to the modeling used by Aydın et al. (2016). The selectivity results in this study were lower for 140 mm in 210d/2 and higher for 150 and 160 mm in 210d/3 nets than the study conducted in Demirköprü Dam Lake by Şen (2016). While our study was carried out in the shallow (4-5 m) lake, Demirköprü Dam Lake is a deeper lake with a depth of 50 m, thus, it is likely that the nutritional differences of the lakes may affect the overall condition, girth, and thus selectivity of the fish. Since the selectivity of 180 and 200 mm mesh size multifilament gillnets are presented here for the first time, this cannot be compared with other studies (Table 5).

Table 5. Selectivity studies conducted on common carp (*: Bar length, ^: These mesh sizes were not used and their modal lengths were determined by modelling, n: Number of fish caught, E: Hanging ratio)

Author	Study area	Method	n	Mesh size (mm)	Material	Model length (cm)
Özyurt and Avşar (2005)	Seyhan Dam Lake	Holt (1963)	294	28*	Monofilament gillnets	17.55
				32*		20.06
				40*		24.44
				45*		27.5
Carol and Garcia-Berthou (2007)	Different Reservoirs in Catalonia	SELECT	116	29	Monofilament gillnets	10.89
				38		14.27
				51		19.15
				64		24.03
				84.5		31.73
				101.5		38.12
				135.5		50.89
				177.5		66.66
				201.5		75.67
				253		95.01
Cilbiz et al. (2015)	Manyas Lake	SELECT	208	100	Monofilament trammel nets	39.05
				110		42.95
				120		46.85
				130		50.76
				140		54.66
Aras (2015)	Keban Dam Lake	SELECT	219	40*	0.12 mm Multi-monofilament gillnets	26.88
				45*		30.24
				50*		33.6
				55*		36.96
				60*		40.32
			232	40*	0.18 mm Multi-monofilament gillnets	27.2
				45*		30.6
				50*		34
				55*		37.4
				60*		40.8
Aydın et al. (2016)	Marmara Lake	SELECT	40	40	Multifilament gillnets	12.98
				60		19.47
				80		25.96
				100		32.45
				110^		35.7
				120^		38.94
				130^		42.19
				140^		45.43
			79	40	Multifilament trammel nets	12.4
				60		18.6
				80		24.8
				100		31
				110^		34.1
				120^		37.2
				130^		40.3
				140^		43.4
Şen (2016)	Demirköprü Dam Lake	SELECT	239	65*	Multifilament gillnets	53.29
				70*	(210d/2)	57.39
				75*	(210d/3)	61.49
				80*	(210d/3)	65.59
Dartay and Ateşşahin (2017)	Keban Dam Lake	Holt (1963)	142	45*	Multi-monofilament gillnets (E=0.5)	29.72
				50*		33.02
				55*		36.32
				60*		46.62
			116	45*	Multifilament gillnets (E=0.5)	29.33
				50*		32.58
				55*		35.84
				60*		37.10
			117	45*	Multi-monofilament gillnets (E=0.67)	30.47
				50*		33.86
				55*		37.24
				60*		40.63
			103	45*	Multifilament gillnets (E=0.67)	28.61
				50*		31.79
				55*		34.96
				60*		38.64

Table 5. Continued

Author	Study area	Method	n	Mesh size (mm)	Material	Model length (cm)
Present study	Marmara Lake	SELECT	225	140	Multifilament gillnets (210d/2)	56.59
				150		60.56
				160		64.59
				180		72.67
				200		80.74
			165	140	Multifilament gillnets (210d/3)	58.97
				150		63.18
				160		67.39
				180		75.82
				200		84.24

One of the basic principles guiding sustainable fisheries is to allow a stock to reproduce at least once before they are caught to replenish their population. Using this principle, the modal lengths of fishing gears should ideally be higher than the lengths of first maturity (Lm_{50}) and minimum landing size (MLS). Lm_{50} value for common carp in Marmara Lake has not been reported yet in the literature. However, the MLS for common carp under the current national fisheries legislation is 40 cm for all inland water areas (Anonymous, 2020). When the MLS are examined, both thin (210d/2) and thick (210d/3) material gillnets provided modal lengths over the MLS in this study. On the other hand, fishers are not allowed to land undersized specimens in amounts exceeding 5% of total catch weight (Anonymous, 2020). This study showed that the undersized fish ratio in thick nets (4.5%) was lower than the legal limit (5%), while the ratio of undersized fish in thin nets (8%) was higher, when all mesh sizes are considered together. A lower rate of undersized fish (excluding 180 and 200 mm mesh sizes) was found with thicker twine material of the same mesh size. However, the undersized ratios in three mesh sizes (140, 150, and 180 mm) were not below the legal limits, which should be emphasized for improved technical measures pertaining to the sustainability of common carp in Turkey.

Higher CPUE values were obtained in thin nets than thick nets of the same mesh sizes, but this was not significant. Also, interestingly, this study found total CPUE values of the thinner 210d/2 gillnets to be 1.27 times more efficient than the thicker 210d/3 nets. Hamley (1975) and Jensen (1995) also reported thinner nets to have higher catchabilities than thicker ones owing to lower visibility and higher flexibility, as long as the twine is not too thin that it can be easily torn by larger fish.

CONCLUSION

In this study, the thicker net material resulted in higher modal lengths and spread values and lower catching efficiency and selectivity. All twine thicknesses and mesh sizes in this study provided modal lengths above MLS. Thus, these gear types are sufficient for common carp fisheries in Turkey. However, to achieve improved sustainability in the rapidly declining carp fisheries, we recommend the use of thick nets (210d/3) for 140 and 150 mm mesh sizes, and thinner nets (210d/2) for the larger mesh sizes for the common carp gillnet fishery in Marmara Lake.

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AUTHORSHIP CONTRIBUTIONS

Hakkı Dereli: Conceptualization, methodology, formal analysis, writing - original draft preparation, writing-review and editing, software, visualization, project administration. Turhan Kebapçıoğlu: Investigation, writing-review and editing. Yusuf Şen: Investigation, formal analysis, writing-review and editing, visualization. Zeki Serkan Ölçek: Investigation. Ezgi Dinçtürk: Investigation. Aylin Ulman: Writing-review and editing.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest or competing interests.

ETHICS APPROVAL

No specific ethical approval was necessary for this study.

DATA AVAILABILITY

Data availability: For questions regarding datasets, the corresponding author should be contacted.

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