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RESEARCH ARTICLE ARAŞTIRMA MAKALESİ

Selectivity of monofilament gillnets with different mesh sizes used in fishing of pearl mullet, (*Alburnus tarichi* (Güldenstädt, 1814)) in Lake Van

Van Gölü İnci Kefali (*Alburnus tarichi* (Güldenstädt,1814)) avcılığında kullanılan farklı ağ göz açıklığına sahip monofilament sade uzatma ağlarının seçiciliği

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Abstract: This study was carried out between September 2020 and March 2021 to determine the selectivity of monofilament gillnets used in pearl mullet, *Alburnus tarichi* (Güldenstädt, 1814), fishing in Lake Van. The SELECT method was applied to determine the selectivity. The best model for the selectivity of monofilament gillnets used in pearl mullet fishing was determined as the log-normal model. The optimum catch lengths of monofilament gillnets with 20, 22 and 24 mm mesh sizes were calculated as 21.69 cm, 23.84 cm and 26.01 cm, respectively. Catch per unit effort was determined as 10.03 kg/90 m/day at 20 mm, 15.91 kg/90 m/day at 22 mm and 12.99 kg/90 m/day at 24 mm. The average catch per unit effort was determined as 151 unit/90 m/day at 20 mm, 151 unit/90 m/day at 22 mm, and 110 unit/90 m/day at 24 mm. According to the results of optimum catch length and daily average catch per unit effort, using monofilament gillnets with 22 mm mesh size was more convenient for sustainable pearl mullet fishing in Lake Van.

Keywords: Pearl mullet, gillnet, selectivity, Lake Van

Öz: Bu çalışma, Van Gölü inci kefali, *Alburnus tarichi* (Güldenstädt, 1814), avcılığında kullanılan monofilament sade uzatma ağlarının seçiciliğinin belirlenmesi amacıyla 2020 Eylül ve 2021 Mart tarihleri arasında gerçekleştirilmiştir. Seçiciliğin belirlenmesinde SELECT metod kullanılmıştır. İnci kefali avcılığında kullanılan monofilament galsama ağlarının seçiciliği için en iyi modelin log-normal modeli olduğu belirlenmiştir. 20, 22 ve 24 mm ağ göz genişliğine sahip monofilament sade uzatma ağlarının optimum yakalama boyları sırasıyla 21,69 cm, 23,84 cm ve 26,01 cm olarak hesaplanmıştır. Birim av verimi 20 mm de 10,03 kg/90 m/gün, 22 mm de 15,91 kg/90 m/gün ve 24 mm de 12,99 kg/90 m/gün olarak tespit edilmiştir. Adet olarak ortalama birim av verimi 20 mm de 151 adet/90 m/gün, 22 mm de 151 adet/90 m/gün ve 24 mm de 110 adet/90 m/gün olarak belirlenmiştir. Optimum yakalama boyu ve günlük ortalama birim av verimi sonuçlarına göre, Van Gölü'nde sürdürülebilir inci kefali avcılığı için 22 mm ağ göz genişliğindeki monofilament galsama uzatma ağlarının kullanılmasının daha uygun olduğu belirlenmiştir.

Anahtar kelimeler: İnci kefali, monofilament uzatma ağ, seçicilik, Van Gölü

INTRODUCTION

Lake Van, the largest lake in Türkiye with a surface area of 3547 km^2, has a maximum depth of 450 meters and an average of 171 meters. It has extreme water quality characteristics with a pH of 9.5 and a salinity of 21.28‰ (Sarı, 1997). The pearl mullet, *Alburnus tarichi* (Güldenstädt, 1814), which is well adapted to the salty and sodic waters of the lake, is the only species caught in the lake. A total of 33140 tons of fish were caught in the inland waters of Türkiye in 2021 and pearl mullet caught from Lake Van constitutes approximately 1/3 of this figure with 9925 tons (TUIK, 2022). Fishing is one of the major sources of income today (Aura et al., 2018).

Advances in technology and increased catch pressure on fish stocks have led to the overexploitation of many fish stocks in Türkiye and around the globe (Williams, 1998; Mullon et al., 2005; Kılıç, 2014). Regarding sustainable use of fish stocks, it is essential to consider the biological data of fish stocks as well as the features of fishing gear used in fishing. The selectivity of the gillnet is crucial in the sustainable use of fish stocks. Selectivity in gillnets is associated with the shape, size, and behavioral characteristics of the fish, and the colour, hanging ratio and rigging factor of the net. (Rosman and Maugeri, 1980; İlkyaz, 2005).

In the Lake Van Basin, studies to improve the gillnet selectivity were aimed at increasing the mesh size, using different twine thicknesses, or testing different rigging properties (Çetinkaya et al., 1995; Sarı and Tokaç, 2000). Since *A. tarichi* is the only commercial species fished in Lake Van, the contribution of aforementioned studies, which have generally given positive outcomes, has been through the elimination of small individuals rather than species selectivity. It was stated that the minimum mesh size should not be less than 20 mm and the catchable fish length should not be less

than 18 cm for a sustainable pearl mullet fishery in Lake Van (Sarı, 1997). Increases in the average fish size of the pearl mullet population have been determined in recent years (Bozaoğlu et al., 2019). This change in fish size over time is expected to affect selectivity. There is a need to examine the current situation in terms of selectivity. To our knowledge, there is no current study on the selectivity of monofilament gillnets used in pearl mullet fishing. Therefore, the selectivity of monofilament gillnets with different mesh sizes was evaluated in the present study.

MATERIAL AND METHODS

The present study was conducted with 12 fishing operations in Lake Van between September 2020 and March 2021 (Figure 1). In the study, gill nets with 20–22–24 mm nominal mesh sizes were investigated. The technical plan of used nets was given in Figures 2, 3, and 4. Fishing was carried out the coast of Edremit in Lake Van. The nets were deployed at 9:00 a.m. and collected at the same time the following day. The ground of the study area is sandy.

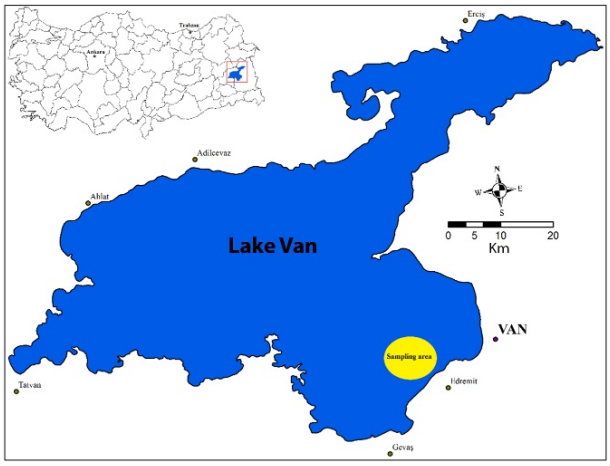

Figure 1. Lake Van and the sampling area

Selectivity Estimation

The SELECT (Share Each Length's Catch Total) method was applied to estimate the selectivity (Millar, 1992; Millar and Holst, 1997; Millar and Fryer, 1999). In this method, as shown in the equation below, the number of fish with *l* length caught in the gillnet with *j* mesh size has an *nlj* Poisson distribution.

$$nlj \approx nlj \approx \text{Pois}\ (pj\ \lambda l\ rj(l))$$

In the equation, *nlj* is the number of fish of length *l* caught in a mesh, *pj* (*l*) is the relative fishing density, and λl is the abundance of fish of length *l* that contacts the gillnet and the number of fish of length *l* caught in the gillnet with *J* mesh of the Poisson distribution is *pj (l) λl*.

The distribution *rj*(*l*) generates the selectivity curve for the j mesh. The log-likelihood function of *nlj* in the equation is calculated as shown below:

$$\sum_{l}\sum_{j}\{n_1\ log[p_j\lambda_i r_j(l)] - p_j\lambda_i r_j(l)\}$$

PASGEAR II software programme (version 2.5; Kolding and Skalevik, 2011) was used in the analysis of the data obtained in the present study. The software makes calculations using 5 different models (normal location, normal scale, log-normal, gamma and bi-modal) (Millar and Fryer, 1999). Among these models, the model with the least deviation was determined as the most suitable model.

Normal location;

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

Normal scale;

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

Log-normal;

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

Gamma;

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

Bi-modal;

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

Calculating Catch Per Unit Effort (CPUE) and YPUE (number of weight)

CPUE and YPUE of gillnets with different mesh sizes was calculated. The CPUE and YPUE for each gillnet group was calculated using the following formula (Godøy et al., 2003).

$$YPUE_i = \frac{ci}{ni\ si} \qquad CPUE_i = \frac{ci}{ni\ si}$$

ci =i. represents the total number of individuals (CPUE) and total weight (YPUE) caught with the tested gillnet group

ni =i. represents the number of gillnet in the gillnet group

si = i. represents the number of days in the gillnet group

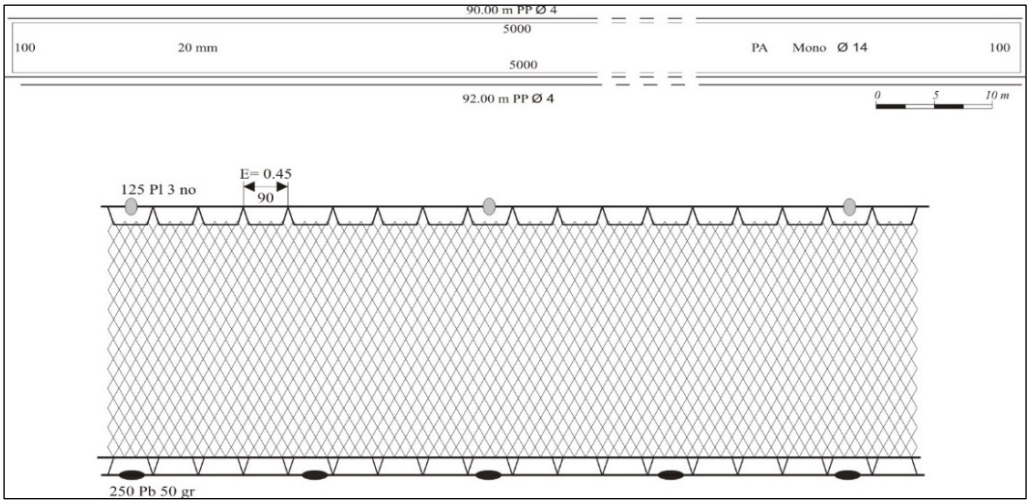

Figure 2. Technical plan of monofilament gillnet with 20 mm mesh size

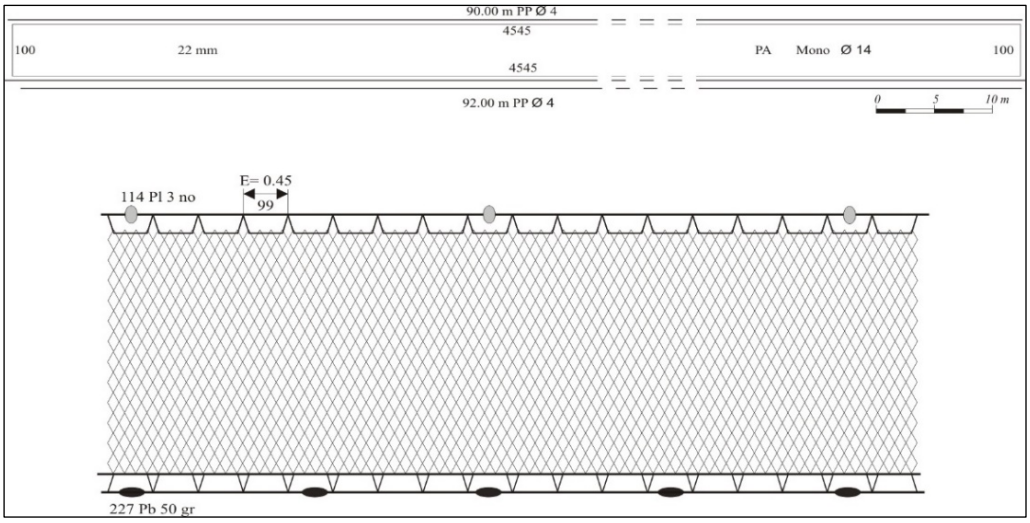

Figure 3. Technical plan of monofilament gillnet with 22 mm mesh size

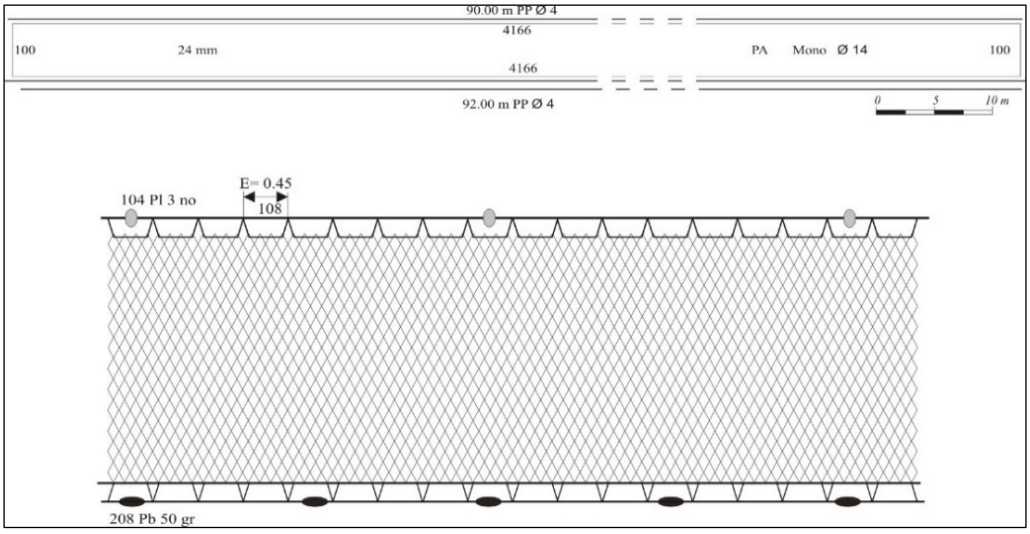

Figure 4. Technical plan of monofilament gillnet with 24 mm mesh size

RESULTS

A total of 4943 pearl mullets (470.3 kg in total) were sampled during the study. Catch data of tested gill nets were given in Table 1.

Table 1. Maximum and minimum length-weight values of fish caught using the gillnets with 20 mm, 22 mm and 24 mm mesh sizes

Mesh size (mm)	Number of fish	Total weight (kg)	Minimum length (cm)	Maximum length (cm)	Average length (cm)
20	1810	123.5	17	25	19.78 ± 1.32
22	1811	190.9	19	27	22.50 ± 1.36
24	1322	155.9	19	28	23.23 ± 1.39

According to the SELECT method, the most suitable method was determined as the Log-normal model with the lowest deviation (Table 2). In the study, spread values and optimum catch lengths for gillnets with several mesh sizes were given in Table 3 and selectivity curves were shown in Figure 5. According to mesh sizes, the optimum catch length was found as 21.69 cm for 20 mm mesh size, 23.84 cm for 22 mm mesh size, and 26.01 cm for 24 mm mesh size (Table 3).

Table 2. The selectivity parameter values of the pearl mullet

Model	Parameters	Deviance	p-value	Degree of freedom
Normal location	(k, σ) = (1.078, 2.903)	311.059	0,00000	28
Normal scale	(k1, k2) = (1.090, 0.129)	325.096	0,00000	28
Log-normal	(μ1, σ) = (3.090, 0.126)	304.825	0,00000	28
Gamma	(k, α) = (0.016, 66.975)	309.868	0,00000	28
Bi-modal	(k1, k2, k3, k4, w) = (0.469, -0.005, -1.090, 0.129, 846.348	325.096	0,00000	25

Table 3. Optimum catch length and spread values for the most suitable model (Log-normal)

Mesh size (mm)	Optimum catch length (cm)	Spread value (cm)
20	21.69	2.69
22	23.84	2.96
24	26.01	3.22

YPUE and CPUE

YPUE and CPUE values for the number and weight of captured fish with tested gill nets were calculated. According to the results, the YPUE in weight was determined as 10.03 kg/90 m/day at 20 mm mesh size, 15.91 kg/90 m/day at 22 mm mesh size and 12.99 kg/90 m/day at 24 mm mesh size. The CPUE in number/fish was designated as 151 units/90 m/day at 20 mm mesh size, 151 units/90 m/day at 22 mm mesh size and 110 units/90 m/day at 24 mm mesh size.

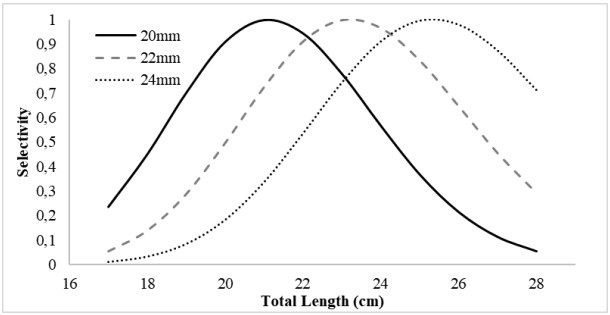

Figure 5. Selectivity curves for mesh sizes

DISCUSSION

Although the natural habitat of pearl mullet is Lake Van, it is indeed a migratory species that migrate from the lake to the streams in flocks during its reproduction period (April-July). Therefore, Pearl mullet fishing is prohibited between April 15 and July 15 in the Lake Van Basin (BSGM, 2020). The distribution of pearl mullet differs according to season. When the lake temperature is high, the fish prefer to live close to the shores between of 3–20 meters, whereas they can be found up to 140 meters in depth during winter months. Since the pearl mullet lives in the deep parts of the lake during the winter months, November, December, January and February, fishing is performed using the multifilament trammel nets. On the other hand, in the summer season fishing is carried out using monofilament gillnets in the areas close to the surface and the coast.

One of the main causes of loss in fish stocks is non-selective fishing gears (Alverson et al., 1994). For the sustainable use of fish stocks, the nets used in fishing should have an accurate mesh size and selectivity that does not harm the stock (Regier and Robson, 1966). Since the selectivity properties of monofilament gillnets used in Lake Van are undetermined, this may put the sustainable use of pearl mullet stock at risk. There is no current study on the selectivity of monofilament gillnets in Lake Van. For this reason, this study was carried out to investigate the effect of different mesh sizes on the selectivity of monofilament gillnets to ensure the sustainability of pearl mullet fishing in Lake Van.

This study determined the optimum catch length as 21.69 cm for 20 mm mesh size, 23.84 cm for 22 mm mesh size, and 26.01 cm for 24 mm mesh size (Table 3). The result of the study on the selectivity of monofilament gillnets in Lake Van conducted by Özdemir (2000) showed that the optimum catch length varied between 14.8–17.1 cm using 18 mm mesh size, and 16.4–19.1 cm using 20 mm mesh size. In another study, Çetinkaya et al. (1995) used 17 mm, 20 mm and 24 mm mesh sizes to determine the catch efficiency and selectivity of multifilament trammel nets used in pearl mullet fishing. The average lengths of the fish caught in the related study were determined as 15.6 cm, 20.2 cm and 20.8 cm, respectively

(Çetinkaya et al., 1995). The values obtained in the current study are higher than the values acquired from the previous studies conducted in Lake Van. Avşar (2005) stated, a decrease in the size of the fish that constitute the stock is the most obvious indicator of overfishing. In recent years, it was reported that the average length of the pearl mullet has increased with the effective conservation measures over the years in Lake Van (Bozaoğlu et al., 2019). This situation was interpreted that the difference being due to the increase in the size of the pearl mullet because of the conservation efforts.

The optimum catch length calculated from all gillnet groups was determined higher than the first reproduction length of pearl mullet. Therefore, it is not anticipated that the monofilament gillnets used in Lake Van will cause any damage to the pearl mullet stock of Lake Van. However, the results of the present study showed that the average catch per unit effort for 22 mm mesh size was higher than gill net groups. Sarı (1997) reported that the average catch per unit effort was 3.538 kg/90 m/day for the 1994-1995 fishing season and 2.677 kg/90 m/day for the 1995-1996 fishing season in Lake Van. According to another report conducted by Çetinkaya et al. (1995), the results were reported as 881.4-4747.6 g/90 m/24 hours at 17 mm mesh size, 680-7608.3 g/90 m/24 hours at 22 mm mesh size, and 1684.3-2367.7 g/90 m/24 hours at 24 mm mesh size. There were notable differences between the average catch per unit effort obtained in the current study and previous reports. The most important reason for this remarkable difference is the structure of the mesh material used in these studies. While other studies used multifilament trammel nets, monofilament gillnets were utilized in the present study. As it is well known, it has been reported that the selectivity of gillnets is better than that of trammel nets (Sürer and Kuşat, 2013).

CONCLUSION

Lake Van is the biggest fishing area in the inland water of Turkey. There are more than 100 fishing boats in the lake. The use of gillnets with appropriate mesh size in the lake where intensive fishing activities are carried out is important for fisheries management and sustainability.

Consequently, according to the data obtained in this study, for sustainable and efficient use of stocks, we recommend using 22 mm and above for monofilament gillnets in pearl mullet fishing in Lake Van.

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AUTHORS CONTRIBUTION

Mustafa Akkuş: Data acquisition, statistical analysis, writing – review & editing. Ahmet Raif Eryaşar: Hardware-software implementation, statistical analysis, validation, editing. Adem Sezai Bozaoğlu: Data acquisition, writing, review and editing.

STATEMENT OF CONFLICT OF INTEREST

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

ETHICS APPROVAL

The research was approved by Van Yüzüncü Yıl University Animal Experiments Local Ethics Committee in terms of sampling and use of experimental animals with decision number 2/2 at the meeting held on 03.10.2019. All researchers declare that all trials were conducted in accordance with ethical values.

DATA AVAILABILITY

The corresponding author should be contacted for questions about datasets.

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