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Research Article Araştırma Makalesi

Length-weight Relationships and Condition Factors of Çaltıcak (Taşkısığı) Lake (Sakarya, Türkiye) Fish Species

Çaltıcak (Taşkısığı) Gölü (Sakarya, Türkiye) Balık Türlerinin Boy-ağırlık İlişkileri ve Kondisyon Faktörleri

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Abstract: Length-weight relationships (LWRs) and Fulton condition factor (CF) of 8 fish species belonging to different families (*Bilicca bjoerkna*, *Scardinus erythrophthalmus* and *Carassius gibelio* from Cyprinidae, *Esox lucius* from Esocidae, *Silurus glanis* from Siluridae, *Perca fuliviatilis* from Percidae, *Abramis brama* from *Leuciscidae*) obtained from commercial fishermen in Çaltıcak (Taşkısığı) Lake (Sakarya/Türkiye) were examined. LWRs and CF of the fish species were analyzed between March 2021 and March 2022. *C. gibelio* and *E. lucius* show positive allometric growth, *B. bjoerkna*,*S. glanis* and *P. fuliviatilis* and *A. brama* showed negative allometric growth, while *S. erythrophthalmus* and *T. tinca* show isometric growth. The lowest CF values of the fish species were also determined in *S. glanis* (0.62) and *E. lucius* (0.69). It is thought that the information obtained in the study about the LWRs and CF values of the fish species in Çaltıcak Lake will be beneficial for commercial fishing and fisheries management in the region.

Keywords
- Çaltıcak Lake
- Fulton's condition factor
- LW

Özet: Çaltıcak (Taşkısığı) Gölü'nde (Sakarya/Türkiye) ticari balıkçılık yapan balıkçılardan elde edilen farklı familyalara ait 8 balık türünün (Cyprinidae'den *Bilicca bjoerkna*, *Scardinus erythrophthalmus* ve *Carassius gibelio*, Esocidae'den *Esox lucius*, Siluridae'den *Silurus glanis*, Percidae'den *Perca fuliviatilis*, Tincidae'den *Tinca tinca* ve Leuciscidae'den *Abramis brama*) boy-ağırlık ilişkileri (LWR) ve Fulton kondüsyon faktörü (KF) incelenmiştir. Balık türlerinin LWR'leri ve KF'leri Mart 2021-Mart 2022 tarihleri arasında analiz edilmiştir. *S. erythrophthalmus* ve *T. tinca* izometrik büyüme gösterirken, *C. gibelio* ve *E. lucius* pozitif allometrik, *B. bjoerkna*, *S. glanis* ve *P. fuliviatilis* ve *A. brama*'nın negatif allometrik büyüme gösterdiği tespit edilmiştir. Balık türlerinin en düşük KF değerleri *S. glanis*'de (0.62) ve *E. lucius*'a (0.69) da belirlenmiştir. Çalışmada, Çaltıcak Gölü'ndeki balık türlerinin LWR'leri ve KF değerleri hakkında elde edilen bilgilerin, bölgedeki ticari balıkçılık ve balıkçılık yönetimi açısından yarar sağlayacağı düşünülmektedir.

Anahtar kelimeler
- Çaltıcak Gölü
- Fulton kondüsyon faktörü
- LWR

1. INTRODUCTION

Çaltıcak (Taşkısığı) Lake spreads over an area of 90 hectares within the borders of Sakarya province in western Türkiye. It is mainly fed by groundwater coming from the bottom. Its maximum depth is 5-6 m. The northern shores of the lake, whose southern part is deeper, are reeds and swamps. It expands in winter and contracts in summer. The lake has freshwater characteristics. Çaltıcak (Taşkısığı) Lake is a pond where commercial fishing activities are intensely carried out.

Freshwater resources play an important role in supporting biodiversity and livelihoods of human communities around the world, especially those in rural and poor communities. 56 million people are engaged in small-scale freshwater fisheries in the developing world (Béné et al., 2010).

Fishing activities address the economic, social and biological factors that affect fish stocks by adopting a strategy that meets the nutritional needs of communities without destroying fish stocks (FAO, 2003). In addressing this, the cornerstone tool for research and management includes biometric studies that provide information for an estimated assessment of the biomass of fish species (Zargar et al., 2012). In biometric studies, it is necessary to determine the growth characteristics of the fish in terms of weight and length, as well as the welfare status of the species, which is affected by different biological and environmental factors (Morato et al., 2001). Length-weight relationships (LWRs) are considered an important tool in fisheries sciences, especially in ecology, population dynamics and stock management (Froese, 2006; Abdoli et al., 2008; Epler et al., 2009). This relationship allows estimating the weight of a sample when its total length is known (Nadaf et al., 2013). Additionally, this relationship is used (i) to estimate the growth type (isometric and allometric) from the length and weight of the fish (Ricker, 1975), (ii) to determine the condition of the fish, and (iii) to compare the historical characteristics and living conditions of a fish species in different areas/regions (Petrakis and Stergiou, 1995; Goncalves et al., 1997; Hossain et al., 2015) (iv) also, these values are required for Yield per Recruit analysis in stock assessment studies (Alam et al., 2022). Comprehensive LWRs studies are needed to maintain a healthy commercial stock. Additionally, the condition factor (CF) is also useful for collecting stock composition, lifespan, growth, maturity and production information. LWRs and CF are very effective tools in fisheries biology to implement effective guidelines for sustainable fisheries management in natural water resources (Rajput et al., 2019).

CF is standard practice and is based on the analysis of length-weight data in fisheries ecology. It assumes that heavier fish of a given length fare better. In other words, CF allows quantitative comparison of the fitness of two or more populations from different regions (Neff and Cargnelli, 2004). Hence, the aim of this study was to 1) estimate LWRs for 8 the fish species (including three species from Cyprinidae and other species from the families Esocidae, Siluridae, Percidae, Tincidae, and Leuciscidae) obtained from Çaltıcak Lake, 2) evaluate CF and determine suitability. This information will contribute to the management and conservation of this water resource and will allow future comparisons between natural populations of these fish species' stocks which have economic importance.

2.MATERIALS AND METHODS

2.1.Sample collection

Sampling area, Çaltıcak (Taşkısığı) Lake is located within the borders of Sakarya province (40° 50' 25" N, 30° 27' 59" E) and 90 ha (Figure 1). In the study, a total of 11 hunting operations were carried out with plain (galsama) gillnets with 32-40-50-60 and 80 mm mesh size. A total of 11 samples were made in the selected locations within the fishing operation area in December 2021, January, February and March 2022 to represent the entire lake.

The fish samples were placed in 12-liter cold chain plastic containers filled with ice molds on a fishing boat and were immediately transferred to the research laboratory.

In this study, 8 fish species from different families (*Bilicca bjoerkna*, *Scardinus erythrophthalmus* and *Carassius gibelio* from Cyprinidae, *Esox lucius* from Esocidae, *Silurus glan*is from Siluridae, *Perca fuliviatilis* from Percidae, *Tinca* tinca from Tincidae Abramis brama from Leuciscidae) were obtained from commercial fishermen in Çaltıcak (Taşkısığı) Lake. The fish samples were placed in cold chain plastic containers filled with ice molds on a fishing boat and were immediately transferred to the research laboratory.

Figure 1. Sampling area, Çaltıcak (Taşkısığı) Lake.

2.2. Length-weight relationships (LWRs) and Condition factor (CF)

The samples were taxonomically identified in the laboratory according to Kuru, (2004); Kottelat & Freyhof, (2007); Geldiay & Balik, (2009).

Length and weight measurements of fish samples were carried out during field work. The total length of the fish samples was measured with a fish measuring board with an accuracy of 1 mm. Weightlab brand WL-3002L type precision scale with ± 0.01 g accuracy and 3000 g weighing capacity was used for weight measurement.

Student's t-test was used for comparison b value obtained in the linear regression with isometric value (Sokal and Rohlf, 1987): $ts= (b-3)\ Sb$, where ts is the t-test value, b the slope and Sb the standard error of the slope (b). To evaluate the type of isometric growth if b=3.0, negative allometric if b<3.0, and positive allometric if b>3.0, t-student test was used to determine significant differences from the estimated value of b and its 95% confidence interval (Cl) (Zar, 2010).

The statistical relationship between length and weight parameters of fish species was established using the equation $TW=a\times TL^b$. In this equation; TW is the total weight of the fish (g), TL is the total length (cm), a is the intercept and b is the slope of the relationship (Bagenal and Tesch, 1978).

Fulton's CF is used to reveal the condition of the length and weight of fish. It is based on the assumption that heavier fish of a given length are in better condition (Sheikh and Ahmed, 2018). Fulton's CF was calculated for all individuals by the following equation (Fulton, 1911):

$CF = 100TW/TL^3$

2.3. Statistical analysis

The Relationships among the variables were determined using regression analysis (Spearman Rank Correlation). Observed differences were evaluated statistically by t-test in MINITAB software, independently by groups. Statistical differences in CF value among species were tested using one-way analysis of variance (ANOVA, $p<0.05$).

3. RESULTS and DISCUSSION

The length-weight relationships of different freshwater 8 fish species including *Bilicca bjoerkna*, *Scardinus erythrophthalmus* and *Carassius gibelio* from Cyrinidae, *Esox lucius* from Esocidae, *Silurus glanis* from Siluridae, *Perca fuliviatilis* from Percidae, *Tinca tinca* from Tincidae and *Abramis brama* from Leuciscidae were analyzed in Çaltıcak (Taşkısığı) Lake. The most commercial importance among these species are *P. fuliviatilis*, *S. glanis* and *E. lucius* in Çaltıcak Lake (Reis et al., 2019).

A total of 1041 specimens of about 282921.89 kg were collected during the period of study by the freshwater fish in the Çaltıcak (Taşkısığı) Lake, mean LWRs and CF parameters of the for each fish species are given in Table 1. As revealed by the results, the mean lowest total length of fish species was measured 20 cm for *P. fuliviatilis*, while the mean maximum total length was measured 59 cm for *S. glanis*. The mean least weights were measured for *B. bjoerkna* and *S. erythrophthalmus* (141 g), while the mean most weights was for *C. gibelio* (692 g), as shown in Table 1.

The LWRs of fish species can vary temporally or spatially according to size range, reproductive activities, or environmental conditions such as temperature and water quality, food quality, food availability, disease, and competition (Wootton, 2012). In this study, the LWR parameters (a, b), the coefficient of determination (R^2), the growth type and the CF values are shown in Table 1. The "*b*" value shows the shape of the fish according to its conditions, while the "a" value in the fish length-weight relationship equation shows the average condition of the individuals (Avşar, 1998). The "*b*" value gives the growth type. If $b=3$, it is defined as isometric growth (I), if $b>3$, positive allometric growth is defined as A(+), and if $b<3$, negative allometric growth is defined as A(-) (Wootton, 2012). The species used in this study are economically and ecologically important species and discussed in below.

The "*b*" value changed between 1.73 and 3.32 (*P. fuliviatilis- E. lucius*, respectively). *C. gibelio* (b=3.23) and *E. lucius* (b=3.32) had only positive allometric growth (b=3.23; 3.32, respectively), and *S. Erythrophthalmus (b= 2.99)* and *T. Tinca (b=2.97)* had isometric growth while the other fish species (*S. glanis*, *P. Fuliviatilis;* b=1.73*, B. bjoerkna;* b=2.77, *S. glanis*; b=2.81, *A. brama ;* b=2.94)) had negative allometric growth (Table 1, Figure 1). Many studies have emphasized that *B. bjoerkna* showed positive allometric growth (Tarkan et al., 2006; Yılmaz et. al, 2012;Yılmaz et. al, 2015; Okgerman et al., 2012; Reis et al., 2019; Jamali et al., 2015). Also, there were researches indicating that *B. bjoerkna* showed negative allometric growth (Şaşı and Berber, 2012; Litvinenko et al., 2021). It was emphasized that the *b* value of *B. bjoerkna* was lower in eutrophic and relatively shallow lakes and this species were found in shallow parts of warm lakes with vegetation by Sası and Berber (2012). It is possible for B. *bjoerkna* to show negative allometric growth since Çaltıcak Lake is a eutrophic lake with reeds and swamp areas (Yılmaz, 2016). Contrary to this study, Kahraman et al. (2014), found positive allometric growth for *S. glanis* (*b*= 3.22) and negative allometry for *E. lucius* (*b*=2.48) in Sakarya River. Similarly, *P. fuliviatilis* and *A. brama* generally showed to positive allometric growth in many researches. However, we found that *P. fuliviatilis* and *A. brama* had negative allometric growth. Reis at al. (2019) for *P. fuliviatilis* in Sakarya River and Yurchenko and Morozov (2020) for *A. brama* in Volga River found negative allometric growth. It has been reported that variations of "*b*" value in same species or different species might be due to several factors. Growth patterns of species may differ between different populations of the same species or in different years within the same population, depending on food availability (Ricker, 1975), water quality (Mommsen, 1998), biological, temporal and sampling factors (Mehanna and Farouk, 2021), the fish condition, seasonality (Haimovici and Velasco, 2000; Teixeira et al., 2017), diet, sex, health, habitat, gonad maturity, preservation techniques, stomach fullness and locality (Esmaeili, 2001; Sadeghi and Esmaeili, 2018; Al Jufaili et al., 2021). Therefore, differences may occur in the same species and region. The results of different studies investigating the LWRs (a, b, R^2) and CF of the same species of fish in inland waters of different locations are given in Table 2.

The investigation of condition factors of all the 8 fish species revealed that mean Fulton's condition factors (CF) values were between 0.62 (*S. glanis*) and 2.16 (*C. gibelio*) (2.16) (Table 1). Le Cren

(1951) indicated that CF values greater than 1 (CF>1) indicated the good condition of the fish whereas mean CF values lower than 1 (CF<1) is indicative of the reverse nature. The mean CF was above 1 in 8 species, except *E. lucius* (0.69) and *S. glanis* (0.62) from the 8 species used in present study. The best performance of these eight species *were C. gibelio* (2.16) and *B. Bjoerkna* (2.11). In contrast, the lowest performance were *L. lucius* (0.69) and *S. glanis* (0.62). A high value of CF indicates suitable environmental conditions (e.g. habitat and prey availability), while a low CF indicates less favorable environmental conditions (Blackwell et al., 2000). CF values are given in widely varying ranges. Variability in these values is seen even in the same species as can be seen in Table 2. Okgerman et al. (2012) stated that differences in CF result from responses to feeding regime, time of year, greater weight of the female ovary, organisms used, feeding behavior, biological factors, and environmental perturbations. Differences in CF may result from a combination of one or more of the factors mentioned (Al Jufaili et al., 2021). As a result, the value of CF indicates that Çaltıcak Lake has a rich food reserves and convenient environmental conditions for the fish species used in this study except for *E. lucius* and *S. glanis.* Statistically, there was a significant difference among the fish species in terms of CF values. The most significant difference in CF was between *C. gibelio* and *S. galanis,* and *C. gibelio* and *B. bjoerkna.* On the other hand, the CF differences between *E. lucius* and *S. galnis, T. tinca, P. fuliviatilis* and *S. erythrophthalmus* are not significant ($p<0.05$). Additionally, Datta et al. (2013) indicated that fish fed with different diets and much robust fish if CF is greater than 1. Therefore, we can say that *S. erythrophthalmus*, *C. gibelio, P. fuliviatilis, T. tinca* and *A. brama* were fed different and richer nutrient diets than *E. lucius* and *S. glanis* ve these six fish species were much more robust than from the other two fish species.

In the study, lowest R^2 *values* was in *P. fuliviatilis* (0.88) and *S. erythrophthalmus (0.90)*, whereas the highest R^2 *values* were in *C. gibelio* (0.99) and *T. tinca* (0.98) (Table 1, Figure 2). The high value of the coefficient of determination R^2 suggested that the model used for the analysis fits the data, confirming the model's fitness. Knowledge of LWRs and the CF of introduced or invaded species are essential for assessing and appropriately managing alien and native species in an aquatic system (Aminisarteshnizi and Moyo, 2020). The regression analysis showed that *C. gibelio*'s and *T. tinca* length correlated higher with weight than the other species ($p<0.05$) in Çaltıcak Lake (Figure 2).

Table 1. Mean length-weight relationship parameters of the fish species in Çaltıcak Lake ($p<0.05$).

Species	Total Length (cm)		Total Weight (g)		Parameters			*b*(SE)	95 % Cl of *b*	Student t test of *b*	CF±SD	CF (Min-Max)	LWR equations	Growth type	p
	Mean TL±SD	Min-Max	Mean TW±SD	Min-Max	a	*b*	R^2								
B. bjoerkna	21.73±5.63	10.80-52.00	141.35±150.54	10.00-1650.00	0.023	2.77	0.93	2.12	14.21-22.55	7.24	2.11±0.28	0.23-2.11	$TW=0.023L^{2.77}$	A(-)	<0.05*
S.erythrophthalmus	22.02±2.30	16.10-30.00	141.43±47.51	42.00-326.40	0.013	2.99	0.90	12.50	18.70-68.20	3.22	1.49±0.18	0.12-1.59	$TW=0.013L^{2.99}$	I	<0.05*
C. gibelio	30.02±7.02	14.20-40.20	691.95±409.10	58.00-1420.00	0.010	3.23	0.99	83.60	-12.3-321.80	1.82	2.16±0.36	0.21-2.57	$TW=0.0098L^{3.23}$	A(+)	>0.05
E. lucius	54.82±9.43	31.10-73.00	1259.41±629.34	180.00-2480.00	0.002	3.32	0.96	33.20	-22.70-111.90	1.25	0.69±0.10	0.54-0.87	$TW=0.002L^{3.31}$	A(+)	>0.05
S. glanis	58.67±10.03	40.70-83.00	1341.60±625.00	422.00-3142.00	0.013	2.81	0.97	13.60	30.10-85.20	4.03	0.62±0.06	0.53-0.77	$TW=0.0134L^{2.81}$	A(-)	<0.05*
P. fuliviatilis	20.21±3.76	14.60-26.70	119.78±41.90	55.30-230.00	0.640	1.73	0.88	3.15	0.50-13.82	1.28	1.41±0.41	0.91-2.37	$TW=0.6403L^{1.73}$	A (-)	>0.05
T. tinca	33.79±3.62	26.20-37.70	628.58±184.21	289.60-878.00	0.018	2.97	0.98	7.85	39.85-74.04	6.88	1.25±0.06	1.47-1.68	$TW=0.0176L^{2.97}$	I	<0.05*
A.brama	35.58±5.96	26.60-46.50	529.70±276.21	172.00-1156.00	0.013	2.94	0.91	12.30	12.60-64.30	2.88	1.10±0.19	0.89-1.59	$TW=0.0133L^{2.94}$	A(-)	<0.05*

n=sample size, W=total weight (g), a=intercept, *b*=slope, Cl=confidence intervals, R^2=coefficient of determination, CF= Fulton's condition factor, GT=growth type, I):isometric growth, A (+):positive allometric growth, and A(-):negative allometric growth, *<0.05= Regression analysis results are significant

Table 2. Mean length-weight relationship parameters of the fish species in different locations (p<0.05).

Species	n	L(cm) (Min-Max	W (g) (Min-Max)	Lenght-Weight Parameters			Growth (t test)	Location	CF	References
				a	b	R^2				
B. bjoerkna	196	12.00-21.20	-	0.007	3.18	0.90	**A(+)**	Sapanca Lake	-	Tarkan et al., 2006
	434	13.20-27.80	22.80-259.00	0.004	3.36	0.97	**A(+)**	Ladik Lake	1.59	Yılmaz et. al, 2012
	434	13.87-18.72	42.90-112.30	0.007	3.32	0.97	**A(+)**	Ladik Lake	1.49-1.78	Yılmaz et. al, 2015
	1250	8.00-30.00	-	0.033	2.93	0.97	**A(-)**	Kyiv Reservoir	2.68	Litvinenko et al., 2021
	350	6.60-24.30	-	0.004	3.39	0.97	**A(+)**	Sapanca Lake	1.12	Okgerman et al., 2012
	183	7.40-18.50	6.78-124.16	0.115	2.58	0.81	**A(-)**	Uluabat Lake	1.27-2.87*	Sasi and Berber, 2012
	547	6.20-30.40	3.15-311.15	0.015	3.12	0.96	**A(+)**	Sakarya River	-	Reis et al., 2019
	392	13.70-27.80	26.00-289.00		3.44	1E-06	**A(+)**	Aras Dam Lake	-	Jamali et al., 2015
S. erythrophthalmus	19	7.80-22.90	-	0.008	3.21	0.99	**A(+)**	Sapanca Lake	-	Tarkan et al., 2006
	305	6.90-27.00	-	0.008	3.17	0.98	**A(+)**	Büyükçekmece Lake	1.38	Saç and Okgerman, 2016
	270	9.40-17.90	11.98-98.50	0.006	3.29	0.96	**A(+)**	Anzali Lagoon	1.58-2.30*	Aminisarteshnizi&Moyo, 2022
	43	10.20-30.20	13.46-364.67	0.009	3.15	0.99	**A(+)**	Sakarya River	-	Reis et al., 2019
	317	6.80-29.00	3.40-392.70	0.007	3.24	0.99	**A(+)**	Ömerli Reservoir	0.88-1.86*	Gaygusuz, 2018
	141	6.40-17.70	-	0.006	3.36	0.96	**A(+)**	Anzali Wetlands	1.40	Moradinasab et al., 2012
C. gibelio	363	5.20-30.20	-	0.008	3.25	0.99	**A(+)**	İznik Lake	-	Tarkan et al., 2006
	395	9.90-34.50	16.17-774.40	0.012	3.11	0.99	**A(+)**	Büyükçekmece Lake	1.72	Saç and Okgerman, 2016
	95	11.30-35.50	-	0.022	2.88	0.90	**A(-)**	Anzali Wetlands	1.55	Moradinasab et al., 2012
	179	9.30-32.40	13.76-592.75	0.026	2.87	0.97	**A(-)**	Sakarya River	-	Reis et al., 2019
	3987	6.90-38.20	3.70-1266.00	0.011	3.17	0.98	**A(+)**	Eğirdir Lake	-	Apaydın Yağcı et al., 2022
	46	1.90-36.50	113.00-984.00	0.019	3.04	0.88	**A(+)**	Asartepe Dam Lake	2.03	Saylar et al., 2019
E. lucius	13	26.3-57.6	-	0.003	3.21	0.97	**A(+)**	Sapanca Lake	-	Tarkan et al., 2006
	48	40.20-76.30	689.40-3421.50	0.066	2.48	0.94	**A(-)**	Sakarya River	-	Kahraman et al., 2014
	311	22.50-33.39	101.50-319.81	0.023	2.72	0.95	**A(-)**	Çapalı Lake	0.88	Küçük and Güçlü, 2004
	313	22.80-66.00	92.90-3342.00	0.003	3.21	0.98	**A(+)**	Işıklı Dam Lake	0.87	Uysal et al., 2008
	100	16.5-53.4	260.00-1870.00	0.036	2.69	0.998	**A(-)**	Kesikköprü Dam Lake	0.86-1.04*	Altındağ et al., 1999
	44	27.20-259.80	153.16-1353.12	0.0097	2.91	0.93	**A(-)**	Sakarya River	-	Reis et al., 2019
S. glanis	64	22.50-86.70	66.10-5987.60	0.003	3.22	0.99	**A(+)**	Sakarya River	-	Kahraman et al. 2014
	21	20.5-250.0	-	0.032	2.57	0.96	**A(-)**	Seyhan Dam Lake	-	Erguden and Goksu, 2009
	257	92.7-101.8	6578.2-9041.10	0.010	2.91	0.97	**A(-)**	Menzelet Reservoir	-	Alp et al. 2011
	66	48.50-68.32	704.00-6560.00	0.004	3.06	0.96	**A(+)**	Çelik Lake	0.58	Yüngül et al., 2014
	108	24.80-67.90	92.40-2066.50	0.005	3.02	0.99	**A(+)**	İznik Lake	0.60	Uysal et al., 2009
	128	33.80-103.00	165.00-7600.00	0.007	2.99	0.99	**I**	Altınkaya Dam Lake	0.63	Yılmaz et. al., 2007

P. fuliviatilis	11	7.20-21.20	-	0.008	3.20	0.98	**A(+)**	Büyükçekmece Lake	-	Tarkan et al., 2006
	128	10.50-26.20	20.00-615.00	0.0096	3.24	0.989	**A(+)**	Volga River	1.72-2.25*	Yurchenko & Morozov, 2020
	689	5.90-29.30	1.37-449.00	0.006	3.26	0.99	**A(+)**	Büyükçekmece Lake	1.24	Saç and Okgerman, 2016
	858	8.20-27.50	7.16-365.20	0.005	3.36	0.98	**A(+)**	Ladik Lake	1.28	Saygin et al., 2016
	107	11.40-28.70	20.45-370.51	0.015	2.94	0.93	**A(-)**	Sakarya River	-	Reis et al., 2019
T. tinca	68	13.1-35.00	-	0.007	3.45	0.999	**A(+)**	Sapanca Lake	-	Tarkan et al., 2006
	131	19.00-42.90	103.00-1302.00	-	3.05	0.97	**A(+)**	Asartepe Reservoir	1.68	Saylar et al., 2018
	102	5.90-38.60	2.40-783.24	0.008	3.16	0.997	**A(-)**	Sıddıklı Dam Lake	1.30	Yazıcıoğlu and Yazıcı, 2023
	3360	9.00-37.00	13.00-815.00	0.015	2.99	0.99	**I**	Beyşehir Lake	1.51	Balık et al., 2009
	46	15.00-26.50	-	0.06	2.53	0.90	**A(-)**	Anzali Wetlands	1.60	Moradinasab et al., 2012
	1284	12.00-29.00	27.00-403.30	0.06	2.51		**A(-)**	Seyhan Dam Lake	1.58	Erguden and Goksu, 2010
A. brama	21	20.9-39.70	-	0.005	3.35	0.99	**A(+)**	Terkos Dam Lake	-	Tarkan et al., 2006
	184	21.50-45.00	228.00-2044.00	0.028	2.91	0.97	**A(-)**	Volga River	2.01-2.15*	Yurchenko & Morozov, 2020
	143	14.30-53.70	33.35-1977.48	0.007	3.12	0.97	**A(+)**	Sakarya River	-	Reis et al., 2019
	1420	14.00-56.00	50.00-5600.00	0.010	3.21	0.98	**A(+)**	Middle Dnieper	2.21	Khristenko and Kotovska, 2017
	722	8.10-44.60	8.00-1790.00	0.009	3.18	0.99	**A(+)**	Ladik Lake	1.59	Yilmaz et al., 2015

*gives the minumum and maximum CF values for the fish species if the mean of CF values are not given in the reference paper . Other CF values are given as mean CF values.

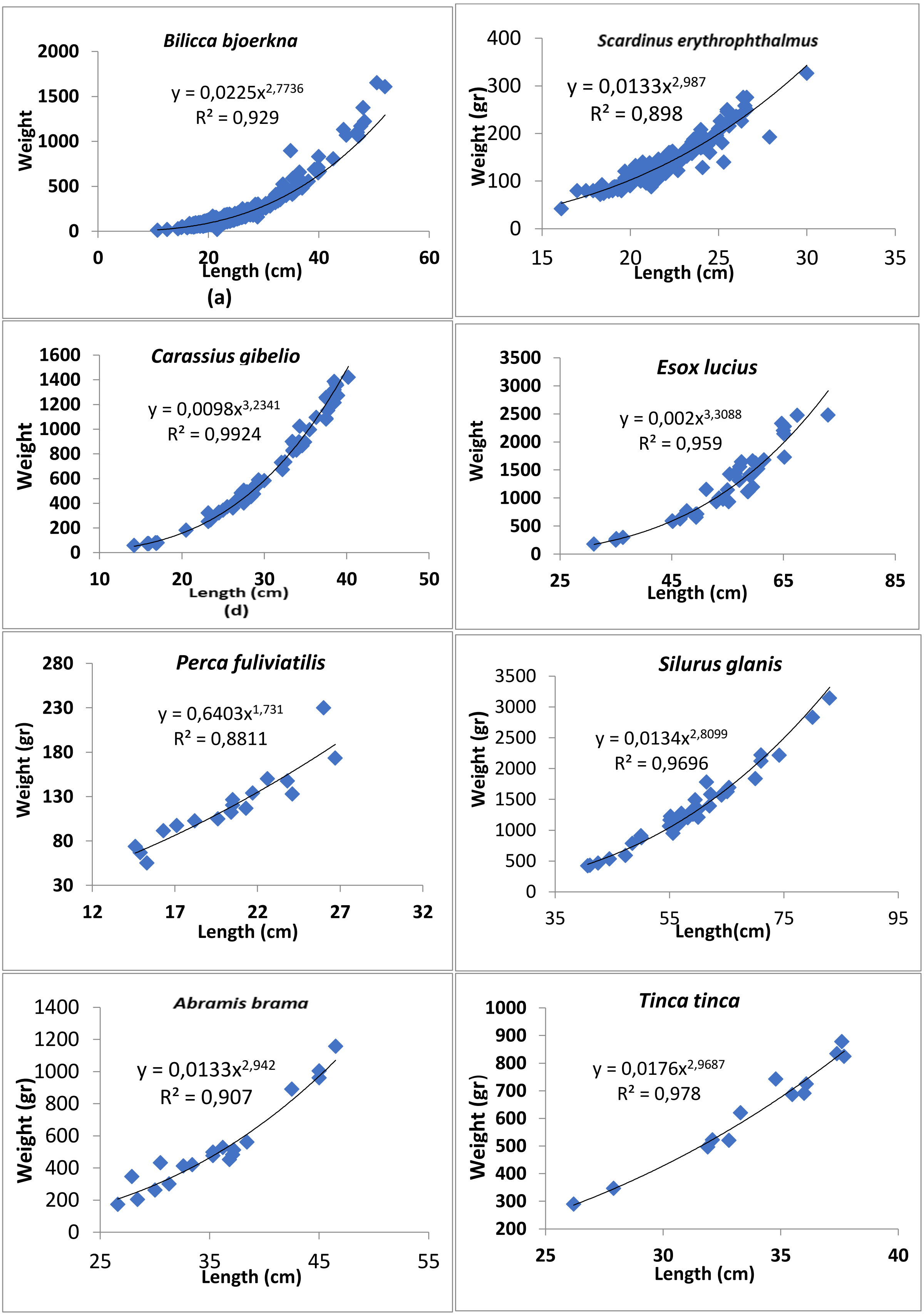

Figure 2. Length–weight relationships of the eight economical fish species from the Çaltıcak (Taşkısığı) Lake.

CONCLUSIONS

This study includes the main information on the length-weight relationships and condition factor of freshwater fish species (*Bilicca bjoerkna*, *Scardinus erythrophthalmus* and *Carassius gibelio*, *Esox lucius*, *Silurus glanis*, *Perca fuliviatilis*, *Tinca tinca* and *Abramis brama*) catching from the Çaltıcak Lake, (Sakarya,Türkiye). There is no study on LWRs and CF in Çaltıcak Lake. Therefore, this study are first research. In this regard, we evaluated that our results will make a positive contribution to the management of freshwater fisheries and related studies to be conducted in the future.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

AUTHOR CONTRIBUTIONS

Experimenting: EA, TÖS; Data analysis: NŞÖ, Manuscript writing: NŞÖ, EA. All authors approved the final draft.

ETHICAL APPROVAL

Ethical approval is not required as this study does not involve clinical research or experimental procedures and the fish samples were obtained from fishermen engaged in commercial fishing activities. No treatment/experimentation was performed on live animals during the study. All samplings and laboratory studies regarding the fish used in the study were carried out in accordance with the Animal Welfare Laws of the Ministry of Agriculture and Forestry of the Republic of Türkiye.

DATA AVAILABILITY

Data supporting the results are available in the manuscript.

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Research Article **Araştırma Makalesi**

A New Strategy: Antibiotic Circumstances for Rational Drug use Against Clinical Aeromonas hydrophila And Bacterial Properties of This Bacteria on Different Agars

Yeni Bir Strateji: Klinik *Aeromonas hydrophila*'ya Karşı Akılcı İlaç Kullanımı İçin Antibiyotik Durumları ve Bu Bakterilerin Farklı Agarlar Üzerindeki Bakteriyel Özellikleri

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Abstract: Antibiotic resistance of *A. hydrophila* was once again observed on different agars. Random antibiotics drug treatment of diseases causes development resistance. Thus, we have faced post-antibiotic era in which our ability to challenge bacteria has diminished and the need for new strategies to deal with disease has increased. *A. hydrophila* ATCC reference strain, which causes the fatal Motil Aeromonas Septicemia (MAS) Disease in fish, was used in the study Colony structure of *A. hydrophila* formed on MacConkey (MAC), Aeromonas Isolation Base Agar (AIBA), Congo Red Agar (CRA) and Blood Agar (BA) were examined. The antibiotic susceptibility was determined by using the Kirby-Bauer method Mueller–Hinton Agar, MAC, AIBA and CRA agar plates. *A. hydrophila* was found sensitive to ciprofloxacin, enrofloxacin, gentamicin, sulphamethoxazole/trimethoprim, and resistant to penicillin G and oxacillin. The important difference was obtained as resistant to enrofloxacin on MAC. Multiple antibiotic resistance index (MARI) of *A. hydrophila* was determined as 0.33 in MHA and 0.5 in MAC. This difference was due to the antibiotic enroflaxin, and its appearance in this study, where a different new approach was tried for the first time, also added originality to the subject. This status may be related to an acquired plasmid. It is important to try to see resistance of *A. hydrophila* by using different agars while innovations such as the AntibiogramJ program are being tried to be added to antibiotic literature.

Keywords
- Motil aeromonas septicemia (MAS) disease
- Antibiotic resistance
- Aeromonas Isolation Base Agar (AIBA)
- Congo Red Agar (CRA)

Özet: Rastgele antibiyotiklerle hastalıkların ilaçla tedavisi direnç gelişimine neden olmaktadır. Böylece bakterilerle mücadele yeteneğimizin azaldığı ve hastalıklarla mücadelede yeni stratejilere olan ihtiyacın arttığı antibiyotik sonrası dönemle karşı karşıya kalmış durumdayız. Araştırma makalesinde, balıklarda ölümcül Motil Aeromonas Septicemia (MAS) Hastalığına neden olan, *A.*

Anahtar kelimeler
- Motil aeromonas septisemi (MAS) hastalığı
- Antibiyotik direnci

hydrophila ATCC referans suşu kullanılmıştır. MacConkey (MAC), Aeromonas Isolation Base Agar (AIBA), Congo Red Agar (CRA) ve Blood Agar (BA) üzerinde oluşan *A. hydrophila* kolonileri incelenmiştir. Antibiyotik duyarlılığı Kirby-Bauer yöntemi Mueller-Hinton Agar, MAC, AIBA ve CRA agar plakları kullanılarak belirlendi. *A. hydrophila* siprofloksasin, enrofloksasin, gentamisin, sülfametoksazol/trimetoprim'e duyarlı bulunurkan penisilin G ve oksasiline dirençli bulunmuştur. Önemli bir fark olarak *A. hydrophila*'nın MAC'ta enrofloksasine dirençli olduğu görülmüştür. *A. hydrophila*'nın çoklu antibiyotik direnç indeksi (MARI) MHA'da 0,33, MAC'da 0,5 olarak belirlendi. Bu farklılık enrofloksasin antibiyotiğinde tespit edilmiş ve ilk kez farklı bir yaklaşımın denendiği bu çalışmada bu durumun ortaya çıkması konuya özgünlük de katmıştır. Bu durumun edinilmiş bir plazmid ile ilgili olabileceği kanaatindeyiz. AntibiogramJ programı gibi yenilikler antibiyotik literatürüne kazandırılmaya çalışılırken, farklı agarlar kullanılarak A. hydrophila'nın direncinin görülmeye çalışılması önemlidir. *A. hydrophila*'nın antibiyotik direnci farklı agarlarda bir kez daha gözlendi.

- Aeromonas Isolation Base Agar (AIBA)
- Congo Red Agar (CRA)

1. INTRODUCTION

Aeromonas hydrophila bacteria are Gram-, facultative, anaerobic straight rods with rounded ends (Sawyer, 2020*). A. hydrophila*, with its cytotoxic and hemolytic exoenzymes, causes infections such as gastroenteritis, vomiting, fever and epigastric pain, as well as septicemia, arthritis, meningitis and peritonitis in humans. *A. hydrophila* complex cause a hemorrhagic septicemia in fish (Fernández-Bravo and Figueras, 2020). Therefore, it has been recently described as "jack-of-all-trades" (Rasmussen-Ivey et al., 2016) alive creatures comorbidity (Janda and Abbott, 2010). This bacteria expressed this way because it is a powerful pathogen in terms of virulence.

Motile Aeromonas Septicemia (MAS) Disease is caused by *A. hydrophila* agent. Gross pathology of MAS can range from few external or internal symptoms in peracute cases to hemorrhagic septicemia, in acute cases, to abscesses, serious wounds, fibrinous peritonitis (Kousar et al., 2022) and ulcers in chronic cases. Severe MAS outbreaks frequently display a range of lesions indicating variation in progression of ailment in fish. Ailment symptoms include septicemia, reddened fins, anus inflammation, tissue hemorrhages, exophthalmia and dropsy in fish. Oedema of scale pockets, scale loss, fin erosion and assist (dropsy) are visible (Hanson et al., 2019; Liu et al., 2020; Mahboub and Tartor, 2020). The agent can survive in mud for 2 months. There is no specific season in which the disease occurs. Morbidity can reach 100%. However, the disease is not absolutely fatal. Mortality does not exceed 40 - 50% even in very adverse environmental conditions for fish. Oxytetracycline 50-75 mg/kg (c.a.) for treatment purposes. It is recommended orally for 10 days. Treatment in line with the antibiogram results; Sulfamerazine at a dose of 200-300 mg / kg (c.a.) for 10 days, Chloramphenicol at 50-70 mg / kg. It can be used at (c.a.) dosage for 5 – 10 days (Mahboub and Tartor, 2020).

The present study aimed to test growth characteristics of *A. hydrophila* on different agar and antibiotic susceptibility in media. Also i t was aimed to test the colony morphology characteristics of *A. hydrophila* on different agar, antibiotics resistance and post-antibiotic epoch antibiotic susceptibility, in media. Additionally aim of the study was to test antibiotic sensitivity , colony morphology differences, biofilm formation of *A. hydrophila* causing MAS was tested on different agars, firstly Mueller-Hinton Agar (MHA) known as Kirby-Bauer Disk Diffusion assay (Antibiogram assay). For this purpose antibiotic susceptibility of *A. hydrophila* was tested on MacConkey (MAC), Aeromonas Isolation Base Agar (AIBA) and Congo Red Agar (CRA) agars. Furthermore , we determined multi-antibiotic resistance of A. hydrophila and investigated the biofilm of this pathogen in

CRA. Also we investigated the colony differences by monitoring the colony morphology of *A. hydrophila* on MAC, AIBA, CRA and Blood Agar (BL) agars.

Briefly, the aim of this study is to emphasize once again the antibiotic sensitivity with the Kirby-Bauer Disk Diffusion test (Antibiogram assay) using Mueller-Hinton Agar (MHA), which is the well-established antibiotic test in the literature as an invariable rule. *A. hydrophila* bacteria was also grown on other agars to determine the antibiotic profile in other agars as well. A dditionally, the present study aimed to introduce practices that give more robust results, such as AntibiogramJ studies on the digital platform, instead of normal ruler measurements, accordingly AntibiogramJ study was carried out as a continuation of this study. Biofilm virulence is an element that remains in chronic diseases, implants, scales, inanimate tissues, and the environment to which it adheres even when the bacteria is not present any longer . Therefore, this study, focused on the profiles of *A. hydrophila* on different agars, and its virulence on CRA was investigated.

2. MATERIALS AND METHODS

2.1. Start-up

A. hydrophila reference strain was used throughout this study. *A. hydrophila* was grown in BHI maintained as frozen stock at -20°C (Stecchini et al., 1993). *A. hydrophila* was studied by bacteriological tests. The strains were identified morphologically and biochemically. In Gram staining assay, coc-shaped Gram+ bacteria Staphylococcus warneri was used as a control strain.2.2. Gram Staining

Bacteria cell strains wer e Gram stained according to proc edure (Bruckner, 2021).

2.3. Inoculum

A. hydrophila was grown on Tryptic Soy Agar (TSA), MacConkey (MAC), Aeromonas Isolation Base Agar (AIBA), Congo Red Agar (CRA) and Blood Agar (BA). Inoculate all plates (TSA, MAC, AIBA, CRA, BA) with test organisms and incubate at 25°C for 24 h aerobically.

2.4. Biofilm on Congo Red Agar (CRA)

CRA medium was prepared with brain heart infusion broth 37 g/L, sucrose 50 g/L, agar 10 g/L and Congo Red indicator 0,8 g/L. Then it was added to the autoclaved BHAI with sucrose. Plates were then observed for dry crystalline black colonies for biofilm producers and red colonies indicating non-biofilm producers (Freeman et al., 1989).

2.5. Antibiogram Assay

A. hydrophila was tested for antibiotic resistance by using Kirby-Bauer method according to the Clinical Laboratory Standards Institute (CLSI, 2016) guidelines (Clinical L.S. Institute, 2016; Mueller and Hinton, 1941). Briefly, Muller-Hinton agar and a panel of 6 antibiotics disks were selected for resistance tests. These 6 antibiotic discs (Oxoid) were ciprofloxacin CIP (5 μg), enrofloxacin (ENR) (5 μg), gentamicin (CN10) (10 μg), penicillin G (P10) (10 μg), sulphamethoxazole/trimethoprim (SXT25) (25 μg), Oxacillin (OX1) (1 μg).

2.6. Multi Antibiotic Resistance Index (MARI)

This was carried out as described with a slight modification. MARI = resistant antibiotics ∣ total antibiotics tested. MARI values> 0.2 indicate existence of isolate(s) from high – risk contaminated source with frequent use of antibiotics while valuesδ 0.2 show bacteria from source with less antibiotics usage (Nguyen et al., 2024).

3. RESULT

3.1. Start-up

The phenotypic characteristics of the *A. hydrophila* strain were determined by conventional assays (Table 1).

Table 1. Phenotypic characteristics of *A. hydrophila* strain.

Assay	Result
Gram stain	-
Morphology	Basil
Motility	+
Catalase	+
Oxidation/Fermentation(O/F)	+/+
Sensitivity to O/129	Resistance (R)

3.2. Gram Staining

S. warneri strain, a Gram^{+} bacteria, was used as a negative control. *A. hydrophila* were Gram^{-}, whereas *S. warneri* were Gram^{+} cocci ($^{-}$control) (Figure 1).

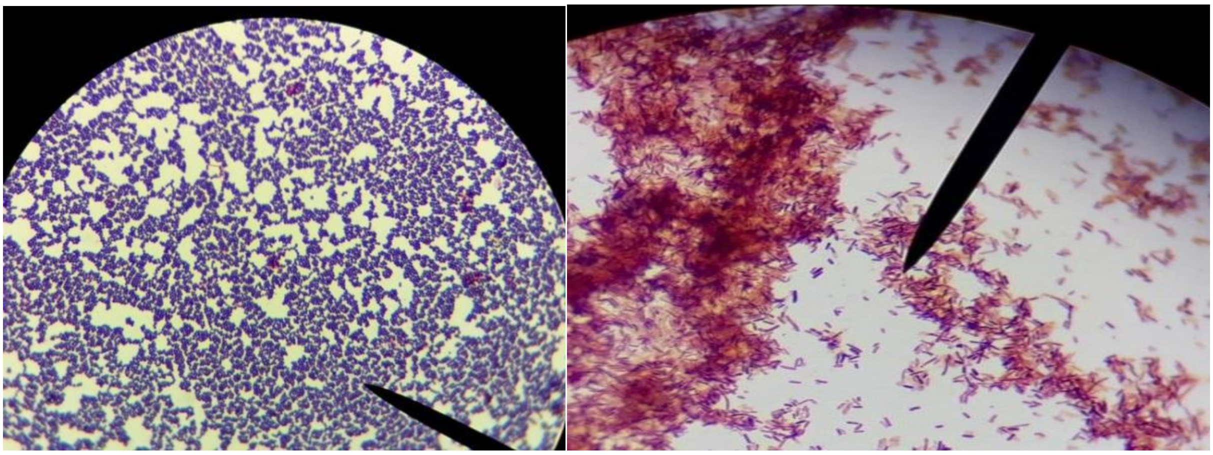
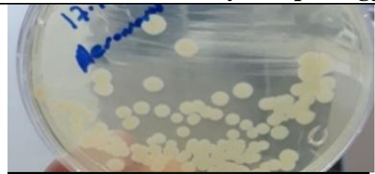
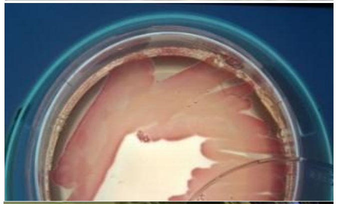
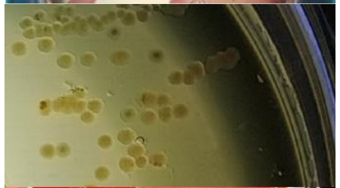
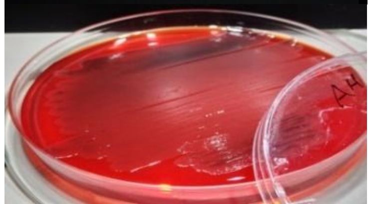


Figure 1. Gram staining of *S. warneri* ($^{-}$control). Gram staining of *A. Hydrophila*.

3.3. Inoculum After

A. hydrophila strain produced cream color colonies on TSA. Lactose posture of *A. hydrophila* monitored in MAC agar. *A. hydrophila* strain produced dark green colonies on AIBA. *A. hydrophila* strain produced red and occasionally weak black colonies on CRA. In BA, *A. hydrophila* that are 1-3 mm in diameter grayish color due to β-hemolysis and dark cream. In BA, colonies are β-hemolytic (Table 2).

Table 2. Colony structures of *A. hydrophila* on TSA, MAC, AIAB, CRA, BL agars.

Bacteria	**Medium**	**Temperature- time**	**Colony structures**	**Colony morphology of *A. hydrophila***	
A. hydrophila	TSA	25°C – 24 h	Growth: Luxuriant Color of colonies: Cream Colony structure: Big, characteristic colony		
A. hydrophila	MAC	25°C – 24 h	Growth: Luxuriant Color of colonies: Colorless pink and occasionally dark pink Colony structure: Big, characteristic colony		
A. hydrophila	AIBA	25°C – 24 h	Growth: Luxuriant Color of colonies: Dark green Colony structure: Opaque with dark centre, characteristic colony		
A. hydrophila	CRA	25°C – 24 h	Growth: Luxuriant Color of colonies: Red, black and occasionally weak black colonies Colony structure: Opaque, characteristic colony		
A. hydrophila	BA	25°C – 24 h	Growth: Luxuriant Color of colonies: cream and occasionally greenish gray Colony structure: Big, circular and convex, β-hemolysis colony		

3.4. Biofilm on Congo Red Agar (CRA)

In this study, in which colony morphology of *A. hydrophila* bacteria on different agars was also evaluated, biofilm was determined in CRA assay, which shows biofilm on agar rapidly in 24 hours. It was determined that *A. hydrophila* bacteria formed a black pigmented colony on the CRA and formed a biofilm (Figure 2).

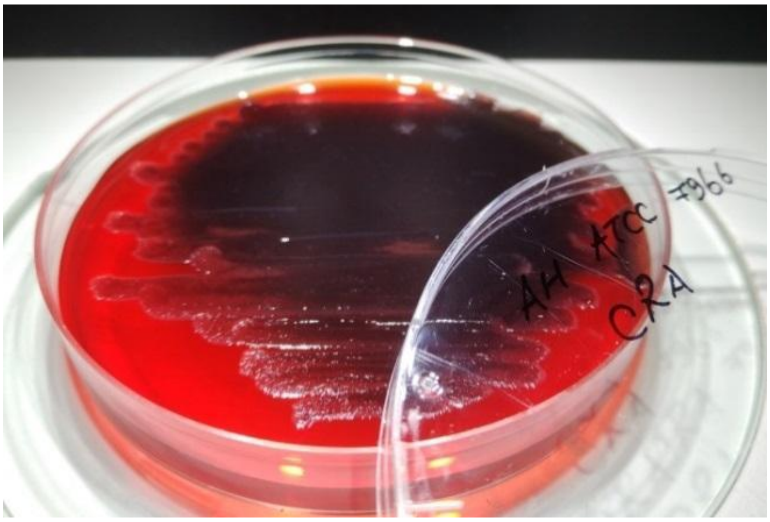


Figure 2. Biofilm production of *A. hydrophila* on CRA.

3.5. Antibiogram assay results

A. hydrophila was sensitive to ciprofloxacin, enrofloxacin, gentamicin sulphamethoxazole/trimethoprim, and was resistant to penicillin G and oxacillin (Figure 3). The resistance of *A. hydrophila* to 2 tested antimicrobial agents is shown in Table 3.

Figure 3. Sensitivity test of *A. hydrophila* to antibiotics on MHA.

3.6. Antibiogram Assay on MAC, AIBA and CRA Agars

Antibiotic sensitivity on MHA is an invariable fact in the literature. For this reason, the antibiotic susceptibility examined in other agars are presented separately in the article, as they are alternatives.

A. hydrophila was sensitive to ciprofloxacin, enrofloxacin, gentamicin sulphamethoxazole/trimethoprim, and was resistant to penicillin G and oxacillin (Table 3). However, *A. hydrophila* was resistant to penicillin G, enrofloxacin and oxacillin on MAC agar (Fig. 4). The sensitivity and resistance of *A. hydrophila* to antibiotics were shown on MAC (Fig. 4), AIBA (Fig. 5) and CRA agars (Fig. 6).

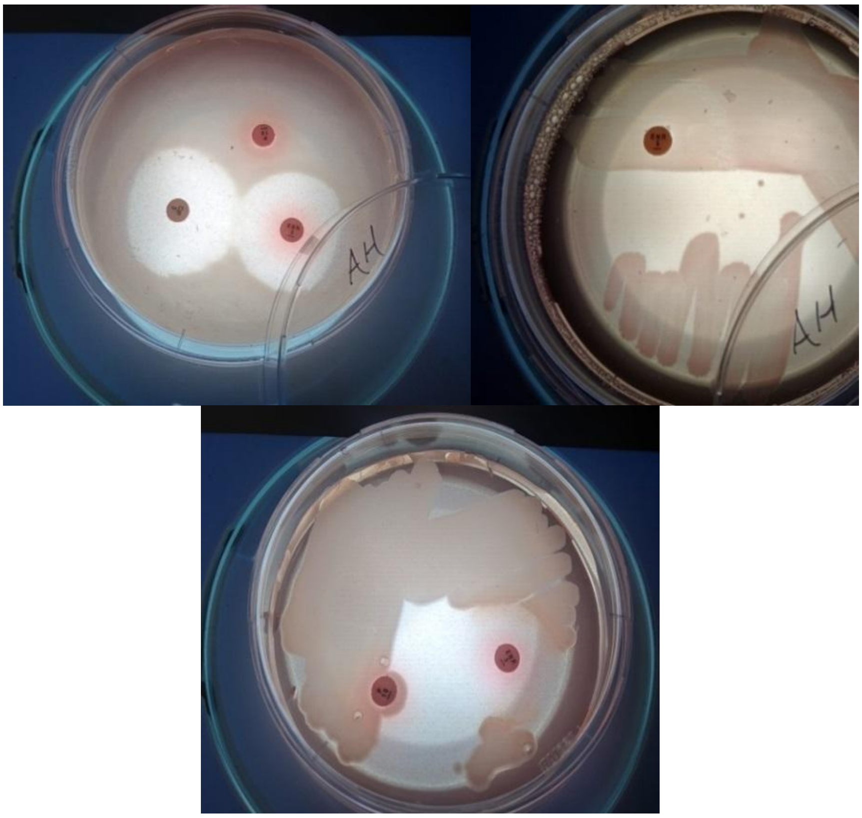


Figure 4. Sensitivity test of *A. hydrophila* to antibiotics on MAC.

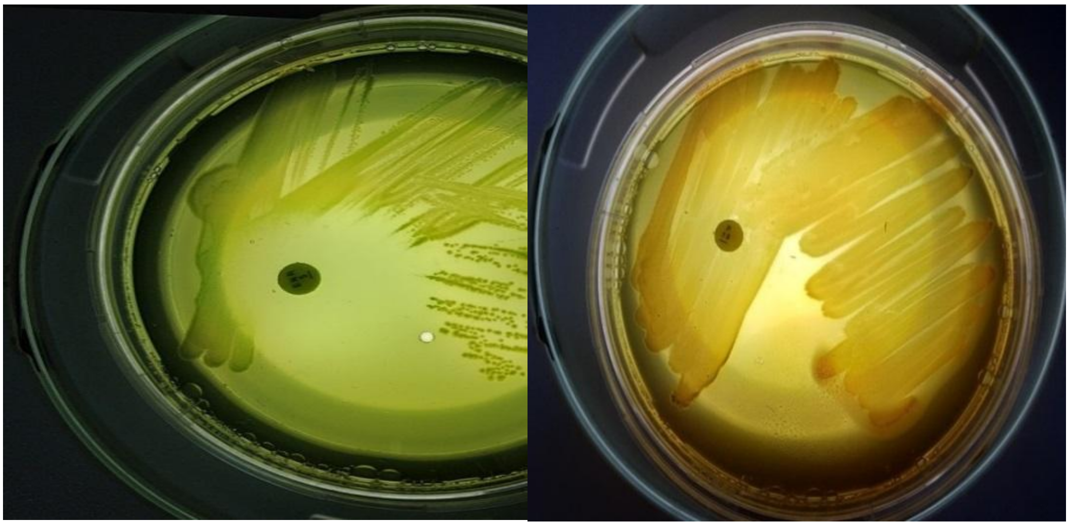


Figure 5. Sensitivity test of *A. hydrophila* to antibiotics on AIBA.

Figure 6. Sensitivity test of *A. hydrophila* to antibiotics on CRA.

Table 3. The antibiotic sensitivity and resistance of *A. Hydrophila*.

Antimicrobial Agent	Code	Disc Content	Test Organisms	Zone Diameter Posture Resistance (R) Intermediate (I) Sensitive (S)			
				MHA	MAC	AIBA	CRA
Ciprofloxacin	CIP5	5 µg	*A. hydrophila*	S (35)	S (35)	S (35)	S (35)
Gentamicin	CN10	10 µg	*A. hydrophila*	S (20)	S (20)	S (20)	S (20)
Enrofloxacin	ENR5	5 µg	*A. hydrophila*	S (30)	S (30) / R (0)*	S (30)	S (30)
Penicillin G	P10	10 µg	*A. hydrophila*	R (0)	R (0)	R (0)	R (0)
Sulphamethoxazole/Trimethoprim	SXT25	25 µg	*A. hydrophila*	S (25)	S (25)	S (25)	S (25)
Oxacillin	OX1	1 µg	*A. hydrophila*	R (0)	R (0)	R (0)	R (0)

*Very important difference

3.7. Multi Antibiotic Resistance index (MARI)

MARI = resistant antibiotics | total antibiotics tested. MARI was 0.33 for MHA. MARI was 0.5 for MAC (Table 4).

Table 4. Multi Antibiotic Resistance index of *A. Hydrophila*.

Test organisms	Multi Antibiotic Resistance index (MARI)			
	MHA	MAC	AIBA	CRA
A. hydrophila	0.33	0.5	0.33	0.33

4. DISCUSSION

There are many agents, methods, causes used for fighting against diseases that have entered the literature. Antibiotics are the most effective elements in treatment of diseases. However, the uncontrolled use of antibiotics has resulted in antibiotic resistance and this is an important problem (Woo *et al*., 2022).

The formation of a community on the surface to which bacteria attach and become mass covered by extracellular polymers is called biofilm. Biofilm is a complex polymicrobial community that can contain different types of bacteria, is surrounded by a polysaccharide matrix produced by these bacteria, and can adhere to surfaces. There are numerous assays used to detect and quantify biofilms in bacteria (Moori *et al*., 2019; Rabha *et al*., 2021). Biofilm is virulence managed by an interbacterial communication system called Quorum Sensing System (QS) (Nurcan, 2010). Black colony was found in *Aeromonas sobria* on CRA (Filik, 2019). Abdulaal in 2019 reported that *A. hydrophila* produced biofilm on CRA. Likewise, in this study, *A. hydrophila* formed a biofilm on CRA.

Antibiogram testing is performed on MHA agar, which is known to be the unchangeable and unalterable rule. AntibiogramJ is the most complete software tool for antibiogram analysis without requiring any particular hardware system. Thanks to features of AntibiogramJ, researchers easily detect when automatic reading has failed and fix it to obtain correct results (Alonso et al., 2017). Here we like to emphasize antibiotic resistance on other agars, similarly to AntibiogramJ approach.

MacConkey agar (MAC) is a bacterial culture medium named after bacteriologist Alfred T. MAC (1861-1931). MAC is selective and differentiating agar that only grows Gram$^-$ bacteria it can further differentiate Gram$^-$ based on their lactose metabolism (Elazhary *et al*., 1973; Jung and Hoilat, 2021). *A. hydrophila* produced colorless colonies as reported in Park *et al*., 2011 report. Sometimes it produces dark pink colonies. In this study *A. hydrophila* produced colonies on MAC, sometimes scattered and sometimes widespread. Colony color varied from colorless pink and occasionally dark pink. This condition has been associated with bacterial gene transfer. In this study, *A. hydrophila* was found to be resistant to antibiotic enrofloxacin on MAC agar. It is a striking result that this bacteria, which is normally sensitive to MHA agar, is resistant to MAC. This situation became prominent with the use of MAC agar instead of MHA agar for the first time.

Aeromonas Isolation Base Agar is based on formulation of Ryan (Ryan, 1985). Thymol blue and bromothymol blue act as monitoring giving characteristic colony color (Himedia, 2020). *A. hydrophila* is complete *A. hydrophila* because of characteristics discovered on AIBA.

The *A. hydrophila* exhibited β-hemolytic activity on blood agar plates (Furmanek-Blaszk, 2014). In this study, *A. hydrophila* showed highly effective β-hemolysis on BA. At the same time, *A. hydrophila* produced greenish gray pigment as reported in Park *et al*., 2011 report.

The studies for antibiotic susceptibility and categorization of bacteria are carried out by international committees such as the Clinical and Laboratory Standards Institute, 2016 or the European Committee on Antimicrobial Susceptibility Testing (EUCAST) (Eucast, 2022). In the first case, breakpoints are published annually, whereas in the second case, they are permanently available and updated annually on its website (http://www.eucast.org/) (Alonso *et al*., 2017).

Dias *et al*. 2018, reported that all *Aeromonas* strains were resistant to ciprofloxacin. In contrast in his study results, *A. hydrophila* were sensitive to ciprofloxacin. This variation can be due to differences in host species and *Aeromonas* strains (Dias *et al*., 2018).

A. hydrophila has multifarious acquired and intrinsic resistance postures against antibiotics (Puzari and Chetia, 2017; Pang *et al*., 2019; Colclough *et al*., 2020; Zahedi bialvaei, 2021).

Results of this antibiotic sensitivity postures assay on *A. hydrophila* were consistent with those reported by other researchers (Trust and Chipman, 1979; Von Graevenitz and Mensch, 1968). Ciprofloxacin, enrofloxacin, gentamicin sulphamethoxazole/trimethoprim would appear to be the treatment of choice.

Antibiotic resistance profiles vary in bacteria (Byarugaba, 2004; Davis and Brown, 2016). Filik *et al*. 2021 reported that *A. hydrophila* showed multi-antibiotic resistance. Likewise, in this study, it was determined that *A. hydrophila* acquired MARI. According to the results of this research MARI was 0.33 for MHA and the MARI was 0.5 for MAC. As in other studies, it was determined that *A. hydrophila* gained MAR in this study as well.

The guardian in 2020 warned that if new antibiotics cannot be developed within the scope of research on antibiotic resistance (Anjuli, 2019), 10 million living things could be at risk from diseases each year by 2050. On the other hand, it is not the strongest or smartest who survive, but one who can adapt most to change. As Megginson (1963) pointed out, the antibiotic resistance adapted to change of environment among bacteria almost reached its peak. Today, over 20,000 potential R genes belonging to 400 different microorganisms are known, antibiotic resistance is an important problem that concerns not only the present but also the future and threatens the whole world. The problem of antibiotic resistance of bacteria in the biofilm matrix that causes infection is one of the major problems faced (Costerton et al., 1999).

Antibiotic resistance is the greatest global threat we face today. Human and animal overuse of antibiotics is a contributing factor and major act change around antibiotic consumption is needed, but several challenges exist in communicating antibiotic resistance to the public. In 2018 UK Government relaunched television advertisement as part of the 'Keep Antibiotics Working' campaign which aimed to raise awareness of antibiotic resistance and reduce public demand for antibiotics. The findings did highlight knowledge gaps amongst research participants including vitality of completing courses of antibiotics as prescribed, and that is bacteria itself, not the person, that develops resistance (Anjuli, 2019). Valuable different results were obtained in our study in terms of differentiating the studies on this subject, which is expected to benefit from television, which is an element of reaching users in the shortest and fastest way by advertising.

As the Royal Society for Biology was forming, antibiotics resistance was being heralded as the next threat with magnitude on par with global warming. In 2016, Jim O'Neill's report was published laying out recommendations for tackling drug-resistant infections globally (Hardie, 2020).

The problem of antibiotic use is as important as other global threats. Since it is a biological problem and is absorbed into the body, it cannot be purified and causes major problems. We believe that this study will support in vivo studies and the literature on antibiotics in terms of investigating different aspects of such an important issue.

5. CONCLUSIONS

The development of the AntibiogramJ program is an important step in terms of digitization and reaching the right result. It is also important to try to see resistance capacity of *A. hydrophila* by using different agars while innovations such as AntibiogramJ program are being tried to be added to antibiotic literature.

The antibiogram assay via MHA (unalterable agar) and in this study has been adapted for use of different agars in determining antibiotic sensitivity. With the antibiogram tested on other agars instead of MHA agar, it was determined that *A. hydrophila* gained resistance on different agars to some antibiotics to which it is normally sensitive. Thus, clearer results were obtained with a different approach.

Biofilm has a very important position in antibiotic treatment. It has now been proven that bacteria in biofilm are many times more resistant to antibiotics. The use of other different agars, especially CRA, in this study also highlights resistance problems.

Antibiotic resistance of *A. hydrophila* was once again observed on different agars. The issue of using antibiotics for treatment rather than prophylactic purposes can be brought up again. İt is already prohibited in the EU the use of antibiotics for other purposes (prophylactic purposes etc.). Random use of antibiotics in drug treatment of bacterial diseases causes development of resistance. Thus, we have faced a post-antibiotic era in which our ability to challenge bacteria has diminished and the need for new strategies and approaches to deal with disease has increased.

HIGHLIGHT

1. Antibiotic resistance of *A. hydrophila* was once again observed on different agars. The issue of using antibiotics for treatment rather than prophylactic purposes can be brought up again.

2. Pathogens are very smart, random use of antibiotics in the drug treatment of bacterial diseases causes the development of resistance. Thus, we have faced a post-antibiotic era.

3. Antibiogram testing is performed on MHA agar, which is an unchangeable and unalterable rule. Here we emphasize the antibiotic resistance of other agars, similarly to the AntibiogramJ approach.

COMPLIANCE WITH ETHICAL STANDARDS

This article does not contain any studies with human participants or animals performed by any of the authors.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ETHİCS COMMITTEE APPROVAL

Ethics committee approval is not required for this research.

FINANCIAL DISCLOSURE

The authors have no financial disclosure to report.

AUTHOR CONTRIBUTION:

Conception/Design of study: NF
Data Acquisition: FF
Data Analysis/Interpretation: FF
Drafting Manuscript: NF
Critical Revision of Manuscript: NF
Final Approval and Accountability: NF/FF/AK
Other Technical or Material Support: NF/FF/AK
Supervision: NF/AK

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Research Article **Araştırma Makalesi**

Oymapınar Baraj Gölü'ndeki (Antalya) Aynalı Sazan (*Cyprinus carpio* Linnaeus, 1758) Popülasyonunun Bazı Biyolojik Özelliklerinin İncelenmesi

Investigation of Some Biological Properties of The Mirror Carp (*Cyprinus carpio* Linnaeus, 1758) in Oymapınar Dam Lake (Antalya)

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Özet: Bu çalışmanın yapıldığı Oymapınar Baraj Gölü, hidroelektrik enerji üretimi amacıyla kurulan baraj göllerinden biridir. Su ürünleri yetiştiriciliği ve avcılığına izin verilmeyen baraj gölünde Nisan 2017 ile Mart 2018 tarihleri arasında ekonomik yönden önemli bir yere sahip olan aynalı sazan (Cyprinus carpio Linnaeus, 1758)'ın yaş, boy ve ağırlık dağılımları ile büyüme ve kondisyonu araştırılmıştır. Örneklenen 128 aynalı sazanın yaşları 0 - IX arasında bulunmuştur. Örneklerin % 50,8'ini dişiler, % 49,2' sini erkekler oluşturmuştur. Dişilerin çatal boyları 14,5 – 66,6 cm, ağırlıkları 73,87 g ile 7089,5 g arasında; erkeklerin çatal boyları 11,2 – 57,7 cm ve ağırlıkları ise 41,73 g ile 5243,31 g arasında değişmiştir. 1. yaştaki örnekler % 26,6'lık bir oranla en baskın yaş grubunu oluşturmuştur. Popülasyonda boy-ağırlık ilişkisi tüm bireyler için W = 0,0356 FL2,8995 şeklinde tespit edilmiştir. Von Bertalanffy büyüme değerleri ise L_∞= 90,15; W_∞= 27841,57; k = 0,076; t0 =-1,403 olarak bulunmuştur. Kondisyon faktörünün 2,33 (Eylül) ile 3,55 (Mart) arasında değiştiği saptanmıştır. İncelemede IV yaş üzerinde örnek sayısının azlığı gölde kaçak avcılığa bağlı av baskısı olduğunu göstermektedir. C. carpio populasyonunun korunabilmesi için denetimin artırılması ve kaçak avcılığın önüne geçilmesi gerekmektedir.

Anahtar kelimeler
- Türkiye
- Baraj Gölü
- *Cyprinus carpio*
- Büyüme özellikleri
- Kondisyon Faktörü

Abstract: This study was conducted in Oymapınar Dam Lake which is one of the dam lakes established for hydroelectric energy production and irrigation. Aquaculture and fishing are not allowed in this Dam Lake. Age, length and weight distributions, growth, and condition of the mirror carp (Cyprinus carpio Linnaeus, 1758), which has an economic importance in this Dam Lake, were investigated between April 2017 and March 2018. The age range of the 128 sampled mirror carp was 0 - IX. 50.8% of the samples were females and 49.2% were males. Fork lengths of females ranged from 14.5 to 66.6 cm, and weights ranged from 73.87 g to 7089.5 g; Fork lengths of males ranged from 11.2 to 57.7 cm, and weights ranged from 41.73 g to 5243.31 g. The I year age group was the most dominant age group, with a rate of 26.6%. The length-weight relationship in the population was determined as W = 0.0356 FL2.8995 for all individuals. Von Bertalanffy growth parameters are L_∞= 90.15; W_∞= 27841.57; k =

Keywords
- Türkiye
- Reservoir
- *Cyprinus carpio*
- Growth characteristics
- Condition factor

0.076; t0 = -1.403. The condition factor was determined to be between 3.55 in March and 2.33 in September. The low number of samples over the age of IV throughout the investigation indicates fishing pressure and poaching in this Dam Lake. In order to protect the C. carpio population, it is necessary to increase control and prevent poaching.

1. GİRİŞ

Ülkemizdeki zengin içsu kaynaklarının su ürünleri açısından büyük bir potansiyele sahip olması nedeniyle birçok baraj gölünde yetiştiricilik ve balıkçılık faaliyetleri yoğunluk kazanmıştır. Ancak su kaynaklarına yapılan müdahaleler, sucul ve karasal ekosistemde bazı olumsuz değişimleri de beraberinde getirmektedir. Özellikle baraj göllerinde yaşayan canlıların büyüme hızı ve üremeleri bu değişimlerden etkilenmektedir. Dolayısıyla müdahalelerin sucul canlılar üzerindeki etkilerini ortaya koyabilmek için, belirli dönemlerde bu değişimlerin izlenmesi gerekmektedir. Ülkemizdeki baraj ve gölet sayısının artmasıyla birlikte baraj ve doğal göllerde hem su ürünleri üretim çalışmaları hem de balık türleri üzerine yapılan biyolojik çalışmalar yoğunluk kazanmıştır.

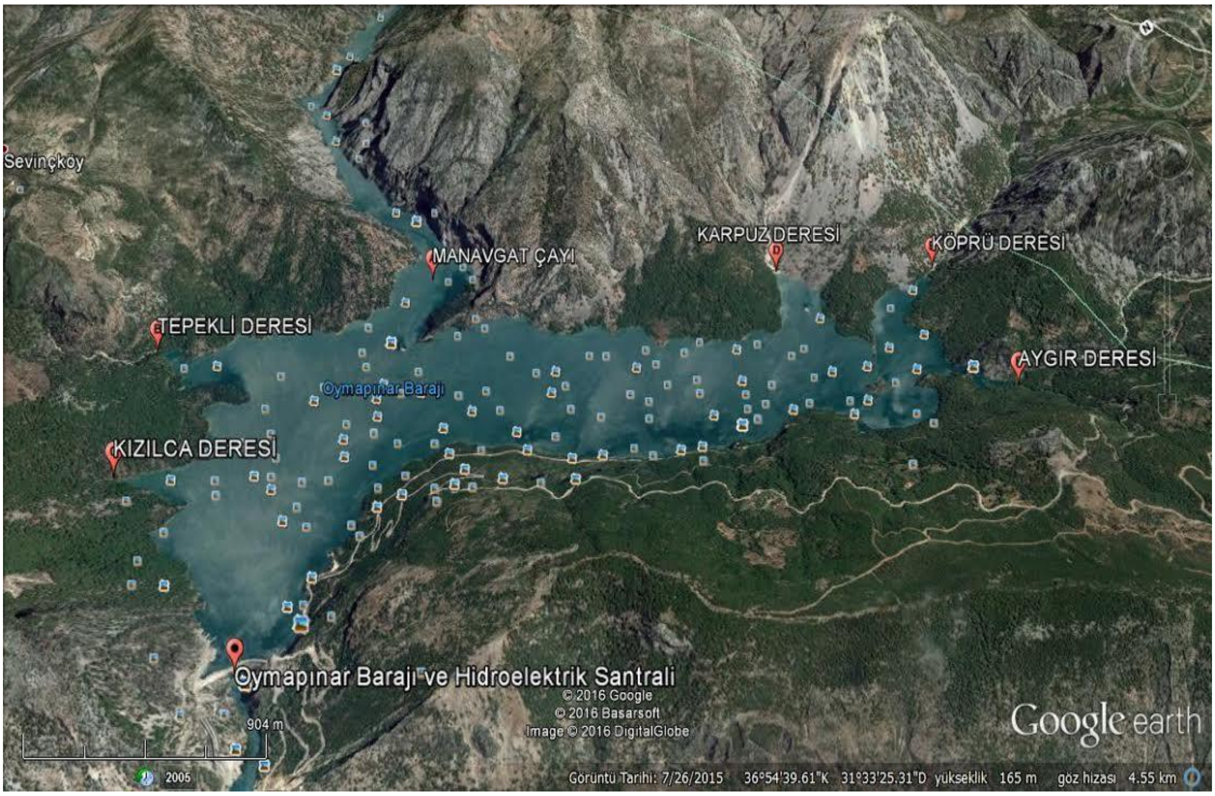
Durgun su sistemlerinde ve akarsuların yavaş akan kesimlerinde yaygın olarak bulunan *C. carpio* balıkçılığımız açısından oldukça önemli bir türdür (Geldiay & Balık, 1999; Yılmaz vd., 2012; Yüce vd., 2016). Oymapınar Baraj Gölü, hidroelektrik enerji üretimi amacıyla kurulan baraj göllerinden biridir. İçme suyu potansiyeli olarak değerlendirilen baraj gölünde su ürünleri yetiştiriciliği ve avcılığına izin verilmemektedir.

Ülkemizde *C. carpio'nun* biyolojik özellikleri üzerine yapılmış çok sayıda çalışma vardır. Ancak Oymapınar Baraj Gölü'nde, Akyurt & Altınok (2009) tarafından yapılan jeolojik araştırma ile Sarı & Becer (2021a, b) tarafından tatlısu kefali ve Erol (2018) tarafından eğrez balıkları üzerine yapılan çalışmalar haricinde bir çalışma bulunmamaktadır. Manavgat Nehri üzerine kurulan bu baraj gölünde avcılık yapılmasa da, sucul ekosisteme yapılan müdahalenin canlıların gelişimi üzerinde ne gibi değişime sebep olduğu bilinmemektedir. Bu çalışma ile; Oymapınar Baraj Gölü'nde yaşayan *C. carpio*'nun yaş, boy ve ağırlık dağılımları ile büyüme ve kondisyonu belirlenmiştir.

2. MATERYAL ve METOT

2.1. Çalışma Sahası

Antalya'nın Manavgat İlçesi sınırları içerisinde bulunan Oymapınar Baraj Gölü, hidroelektrik enerji üretimi amacıyla, 1977-1984 yılları arasında Manavgat Nehri üzerine inşa edilmiştir (Şekil 1). Gövde dolgu tipi beton kemer, gövde hacmi 575.000 m^{3}'dür. 185 metre yüksekliği olan barajın normal su kotunda göl alanı 5 km^{2}'dir. Hidroelektrik santrali 540 MW güç kapasitesiyle bir yılda 1620 GWh elektrik enerjisi üretmektedir (Anonim, 2021). Sulama suyu olarak da değerlendirilen baraj gölünde su ürünleri yetiştiriciliği ve avcılığına izin verilmemektedir.



Şekil 1. Oymapınar Baraj Gölü'ndeki örnekleme yerleri

2.2. Örnekleme Yöntemi

Oymapınar Baraj Gölü'nde yürütülen bu çalışma, Nisan 2017 ile Mart 2018 tarihleri arasında gerçekleştirilmiştir. Avcılık gölü temsil edecek bölgelerden aylık olarak 2,5 m derinlik ve her biri 100'er m uzunlukta olan 50, 60, 80 ve 100 mm göz açıklığındaki monoflament fanyalı ağlar kullanılarak gerçekleştirilmiştir. Ağlar atıldıktan sonra ertesi gün sabah saatlerinde toplanmıştır. Yakalanan örneklerin çatal boy (FL) ölçümleri 1 mm hassasiyetli cetvelle, vücut ağırlıkları ise 0,01 g hassasiyetli elektronik terazi ile tartılmıştır. Balıkların yaşının belirlenmesinde pullardan yararlanılmıştır (Chugunova, 1963).

2.3. Büyüme Özelliklerinin Tespiti

C. carpio bireylerinin eşeylere göre boy ve ağırlıkları, salt ve oransal büyüme olarak tespit edilmiştir. Oransal boy (OFL) ve ağırlık (OW) artışı Chugunova (1963)'nın önerdiği OFL= $(L_t - L_{t-1}/L_{t-1})*100$ ve OW= $(W_t - W_{t-1} / W_{t-1})*100$ eşitlikleri kullanılarak hesaplanmıştır. Eşitliklerdeki Lt: herhangi bir yaştaki ortalama salt boyu (cm), Lt-1: bir yıl önceki ortalama salt boyu (cm), W_t: herhangi bir yaştaki ortalama salt ağırlığı (g), W_{t-1}: bir önceki yıldaki ortalama salt ağırlığı (g) göstermektedir

Tüm bireylerin büyüme performans indeksi $\Phi' = \text{Log } k + 2 \text{ Log } L_\infty$ şeklindeki eşitlikle belirlenmiştir (Munro ve Pauly, 1983). Burada Φ': Fi üssünü ifade etmektedir. C. carpio bireylerinin yaşlara göre boy ve ağırlıkça büyümesi, Beverton ve Holt (1957) tarafından balıkçılığa uyarlanan "Von Bertalanffy" büyüme denklemlerine göre hesaplanmıştır (Beverton & Holt, 1957; Silliman, 1969). Yaş-boy ilişkisi için; $L_t = L_\infty (1\text{-}e^{-k(t-to)})$ eşitliğinden, yaş-ağırlık ilişkisi ise $W_t = W_\infty (1\text{-}e^{-k(t-to)})b$ büyüme denklemleri kullanılmıştır. Bu denklemlerde L(t) = (t) yaşındaki balığın boyunu (cm), W(t) = (t) yaşındaki balığın ağırlığı (g), L_∞= maksimum asimtotik boyu (cm), W_∞ = maksimum asimtotik ağırlığı (cm), k = büyüme katsayısını (yıl–1), to= balık boyunun sıfır olarak kabul edildiği teorik yaşını (yıl)–1 ve "b" boy-ağırlık ilişkisindeki regresyon katsayısını ifade etmektedir (Chugunova, 1963). Boy-ağırlık arasındaki doğrusal ilişki LogW= Loga + b LogFL; üssel ilişki ise $W = a\ FL^b$

şeklindeki denklemlerle hesaplanmıştır. Burada W balığın ağırlığı(g); FL çatal boyu (cm); a ve b büyümeyi ifade eden regresyon katsayılarıdır (Pauly, 1980; Kara, 1992). Kondisyon faktörünün (KF) hesaplanmasında; KF= $(W/FL^3)*100$ şeklindeki izometrik büyüme denkleminden yararlanılmıştır (Lagler, 1966).

2.4. İstatistiki Analizler

Elde edilen veriler SPSS 23.0 ve Microsoft Office Excel istatistik programları ile değerlendirilmiştir. İstatistiki önem kontrolünde P=0.05 güven sınırı esas alınmıştır. Eşey oranlarının karşılaştırılmasında ki-kare (χ^2) testi kullanılmıştır (Düzgüneş vd., 1987; Kaptan, 1995).

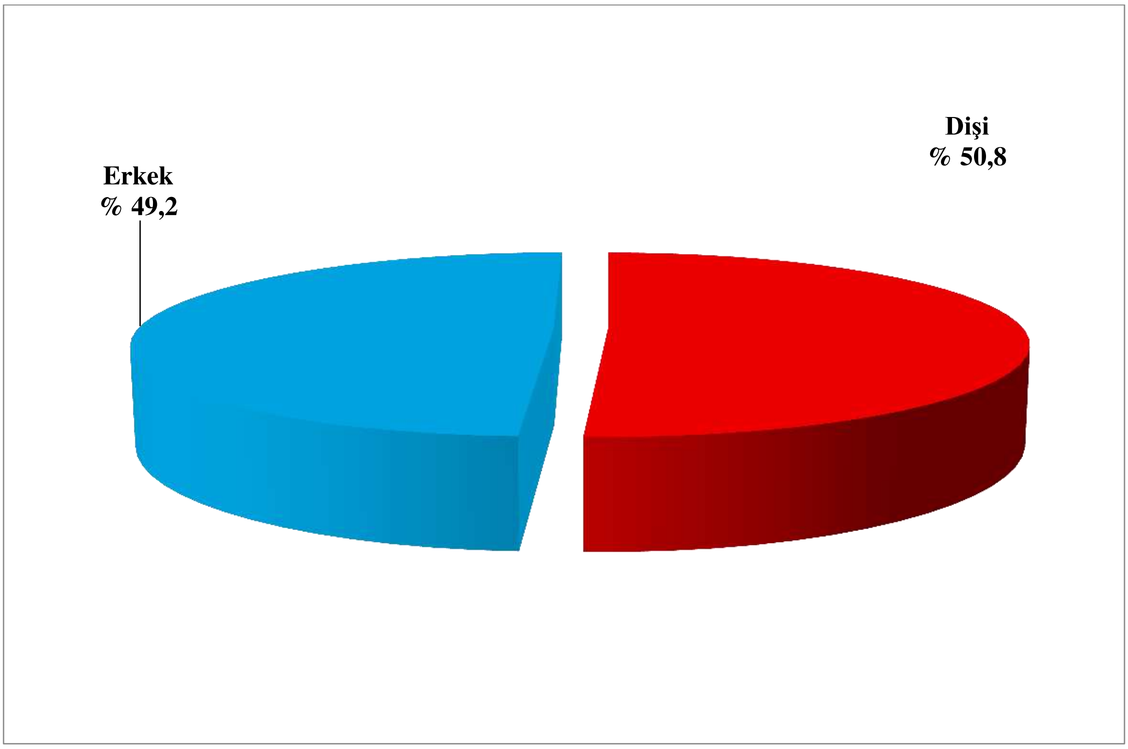
3. BULGULAR

3.1. Örnekleme Bölgesi Balık Faunası

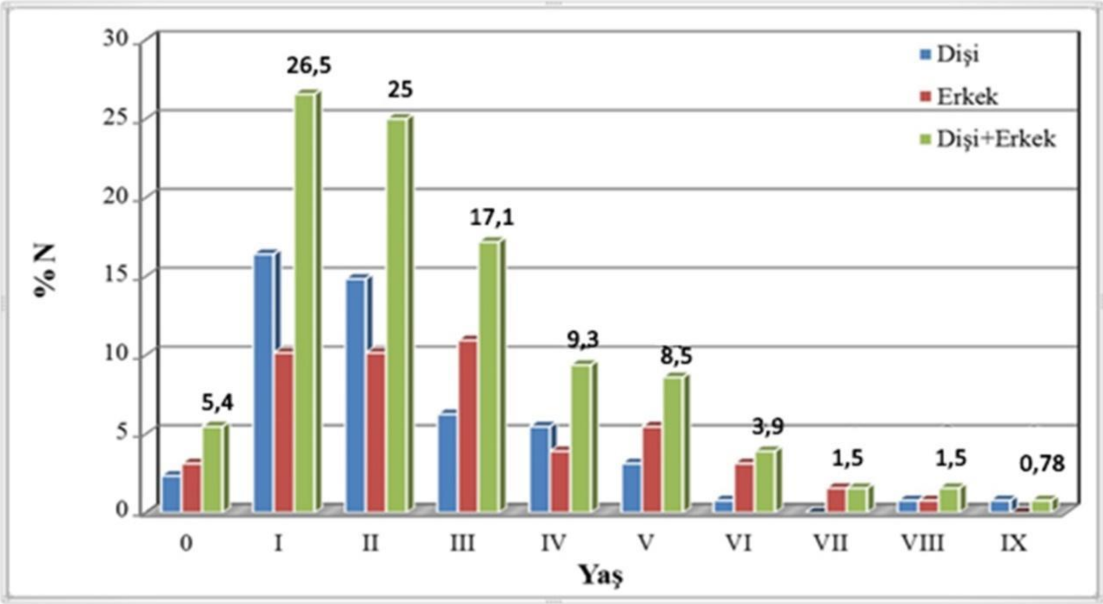
Oymapınar Baraj Gölü'nde Nisan 2017 ile Mart 2018 tarihleri arasında yürütülen bu çalışmada, 4 balık türü tespit edilmiştir. Baraj Gölü'nde en fazla *Squalius anatolicus* bulunmakta olup, bunu sırasıyla *Vimba vimba*, *Cyprinus carpio*, ve *Capoeta caelestis* izlemiştir. Gölde bulunan diğer balık türleri *Pseudophoxinus battalgilae*, *Oxynoemacheilus atili, Salmo* cf. *opimus*, *Alburnus baliki*, *Alburnus escherichii* ve *Carassius gibelio*'dur (Küçük vd., 2020).

3.2. Yaş ve Eşey Kompozisyonu

İncelenen 128 adet *C. carpio* bireyinin yaşları 0 ile IX arasında dağılım göstermiştir. Örneklerin 50,8'ini dişi, 49,2 sini ise erkek bireyler oluşturmuştur (Şekil 2). Yaşlar arasındaki farkın istatistiki açıdan önemsiz (p>0,05) olduğu tespit edilmiştir. Populasyondaki en baskın yaş gruplarının I ve II. yaşlar olduğu, tüm balık örnekleri içindeki oranının ise %51,56 olduğu tespit edilmiştir (Şekil 3).



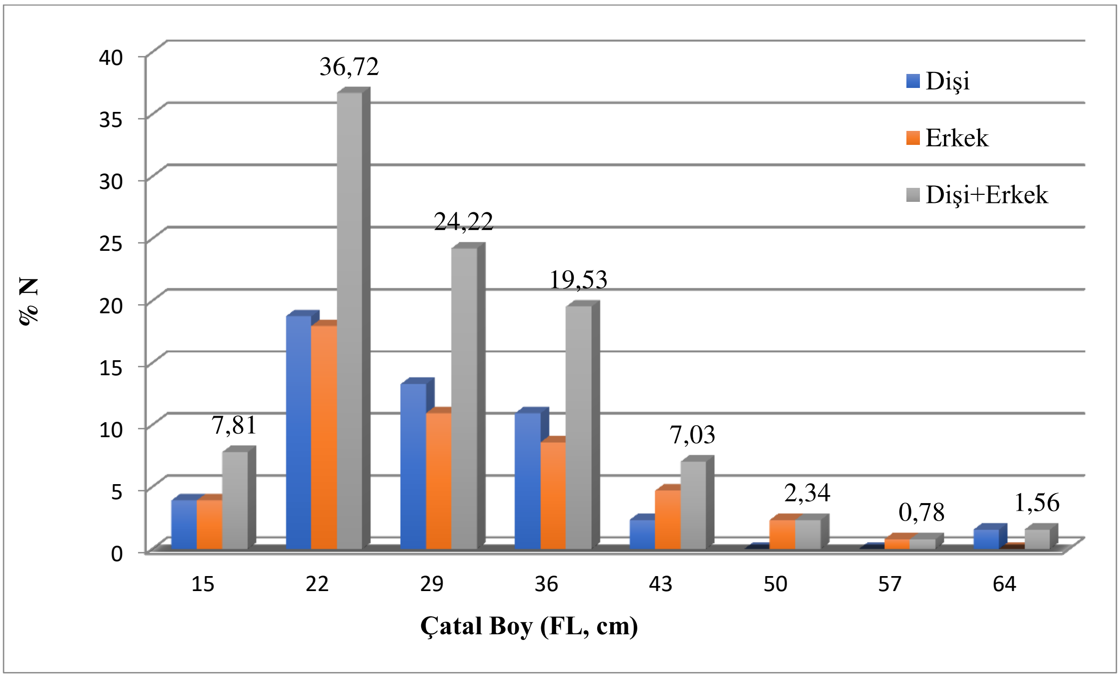
Şekil 2. Oymapınar Baraj Gölü'ndeki *C. carpio* popülasyonunun eşey oranı.



Şekil 3. Oymapınar Baraj Gölü'ndeki *C. carpio* popülasyonunun yaş- eşey dağılımı.

3.3. Boy Dağılımı

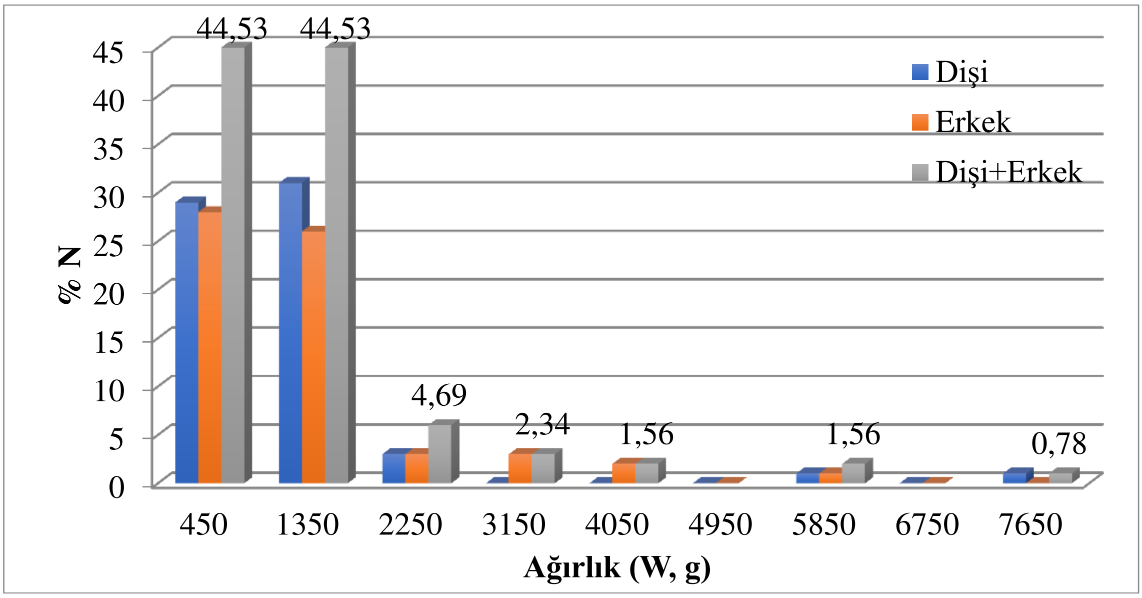
Çalışmada örneklenen 128 *C. carpio* bireyinin çatal boyları 11,2- 66,6 cm arasında değişim göstermiştir. Populasyonda en baskın boy grubunu, 18- 24,9 cm arasında olan bireyler (% 36,72) oluşturmuştur. Araştırmada dişi bireyler 13,4– 66,6 cm, erkek bireyler ise 11,2– 57,7 cm arasında dağılım göstermiştir (Şekil 4).



Şekil 4. Oymapınar Baraj Gölü'ndeki *C. carpio* popülasyonunun boy dağılımı.

3.4. Ağırlık Dağılımı

Oymapınar Baraj Gölü'nden örneklenen toplam 128 *C. carpio*'nun ağırlıkları 41,73- 7089,5 g arasında değişim göstermiştir (Şekil 5). Dişi bireylerin ağırlıkları 73,87 g ile 7089,5 g; erkek bireylerin ise 41,73 g ile 5243,31 g arasındadır. 450 g ile 1350 g ağırlık grubundaki bireyler, incelenen örneklerin % 89,06'sını oluşturmuştur (Şekil 4.4).



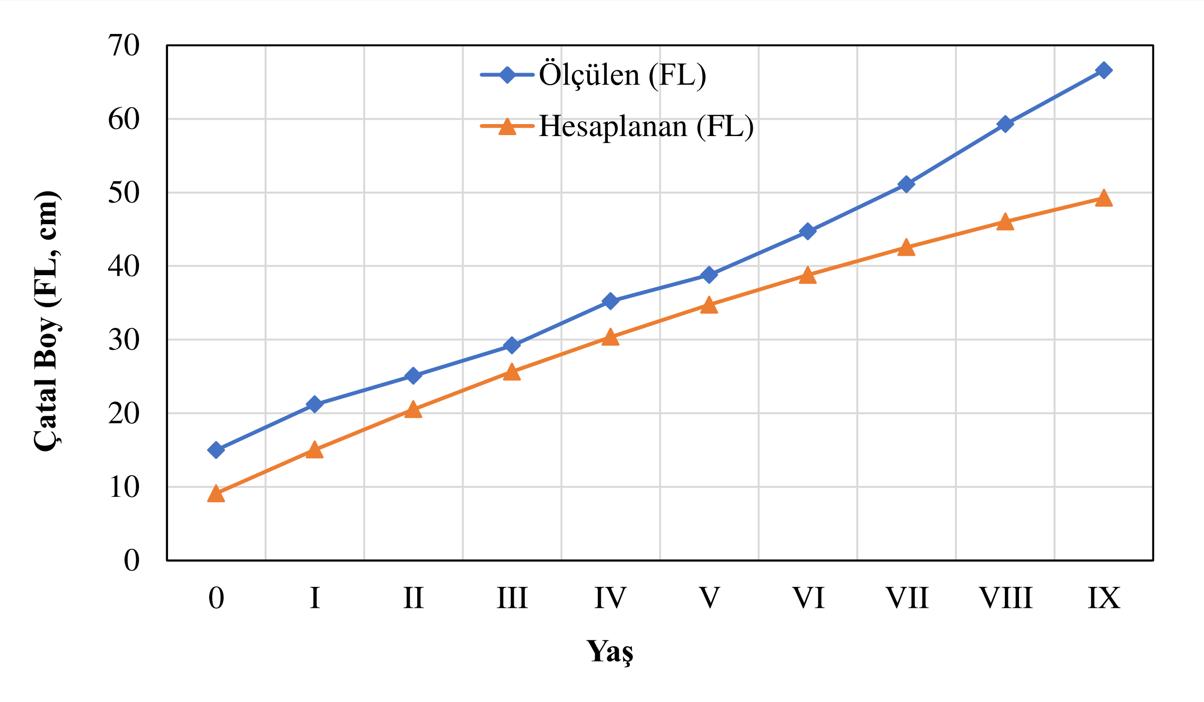
Şekil 5. Oymapınar Baraj Gölü'ndeki *C. carpio* popülasyonunun ağırlık dağılımı

3.5. Yaş - boy İlişkisi

C. carpio bireyinin her yaş grubundaki ortalama çatal boyları, standart sapma ve değişim sınırları ile Tablo 1'de verilmiştir. Ayrıca boyca büyümeleri, von Bertalanffy büyüme denklemi ile hesaplanmış ve büyüme parametreleri $L_\infty = 90{,}15$, k= 0,076, $t_0 = -1{,}403$ olarak bulunmuştur. Dişi-erkek bireylerin yaş-boy ilişkisi eğrisi Şekil 6'da gösterilmiştir.

Tablo 1. Oymapınar Baraj Gölü'ndeki *C. carpio*'nun yaş grupları ve eşey göre ölçülen ortalama çatal boyları (FL, cm), yıllık salt (FL) ve oransal boy artış (OFL).

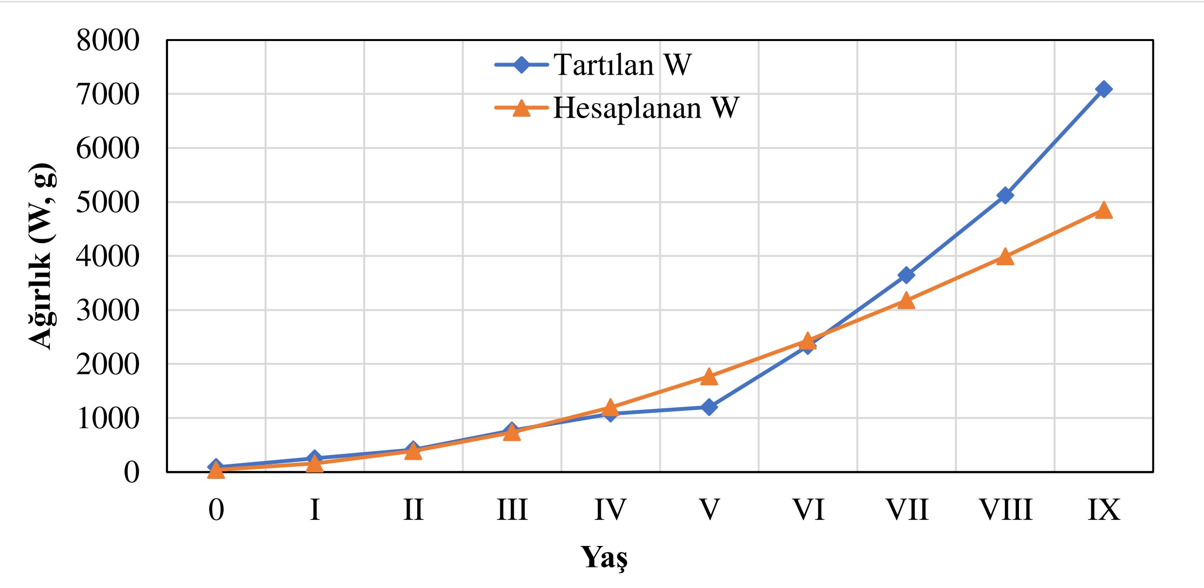
Yaş	Dişi				Erkek				t-test	Dişi + Erkek			
	N	FL±SE (min-mak)	FL	OFL (%)	N	FL±SE (min-mak)	FL	OFL (%)		N	FL±SE (min-mak)	FL	OFL (%)
0	3	15,26 ± 1,35 (13,4-17,9)	-	39,18	4	14,77 ± 1,25 (11,2-17,1)	-	42,78	0,803 p > 0,05	7	14,98 ± 0,85 (11,2-17,9)	-	6,67
I	21	21,24 ± 0,72 (17,3-28)	4,4	20,71	13	21,09 ± 0,63 (17,3-24,9)	3,19	15,12	0,834 p > 0,05	34	21,18 ± 0,50 (17,3-28)	3,91	6,25
II	19	25,64 ± 0,77 (20,5-32,8)	5,08	19,81	13	24,28 ± 0,54 (20,4-27,8)	4,05	16,68	0,164 p > 0,05	32	25,09 ± 0,52 (20,4-32,8)	4,11	5,88
III	8	30,72 ± 1,09 (25,9-34,6)	5,32	17,31	14	28,33 ± 0,86 (24,3-33,6)	5,77	20,36	0,107 p > 0,05	22	29,20 ± 0,71 (24,3-34,6)	6,03	5,56
IV	7	36,04 ± 1,09 (33,1-41,5)	1,43	3,96	5	34,1 ± 0,45 (32,5-35,2)	5,44	15,95	0,185 p > 0,05	12	35,23 ± 0,70 (32,5-41,5)	3,56	5,26
V	4	37,47 ± 0,94 (36,1-40,2)	4,03	10,75	8	39,54 ± ,099 (36,4-42,7)	5,93	14,99	0,203 p > 0,05	12	38,79 ± 0,75 (36,1-42,7)	5,89	5,05
VI	1	41,5		---	3	45,47 ± 1,78 (41,6-50,2)	5,63	12,38	---	4	44,68 ± 1,59 (41,5-50,2)	6,42	4,76
VII		---		---	2	51,1 ± 1 (50,1-52,1)	6,6	12,91	---	2	51,1 ± 1 (50,1-52,1)	8,15	4,54
VIII	1	60,8	5,8	9,53	1	57,7		---	---	2	59,25 ± 1,55 (57,7-60,8)	7,35	8,98
IX	1	66,6								1	66,6		



Şekil 6. Oymapınar Baraj Gölü'ndeki *C. carpio* popülasyonunun tüm bireylerindeki yaş-boy ilişkisi.

3.6. Yaş - ağırlık İlişkisi

Oymapınar Baraj Gölü'nden yakalanan 128 adet *C. carpio* bireyinin yaş grupları ve eşeylerine göre ortalama ağırlıkları ile oransal ağırlık artış değerleri Tablo 2'de verilmiştir. Von Bertalanffy ağırlıkça büyüme parametreleri ise W_{∞}= 27.841,57, k = 0,076, $t_{0=}$ -1,403, b = 2,87 olarak bulunmuş olup, ağırlıkça büyüme eğrisi Şekil 7'de verilmiştir.



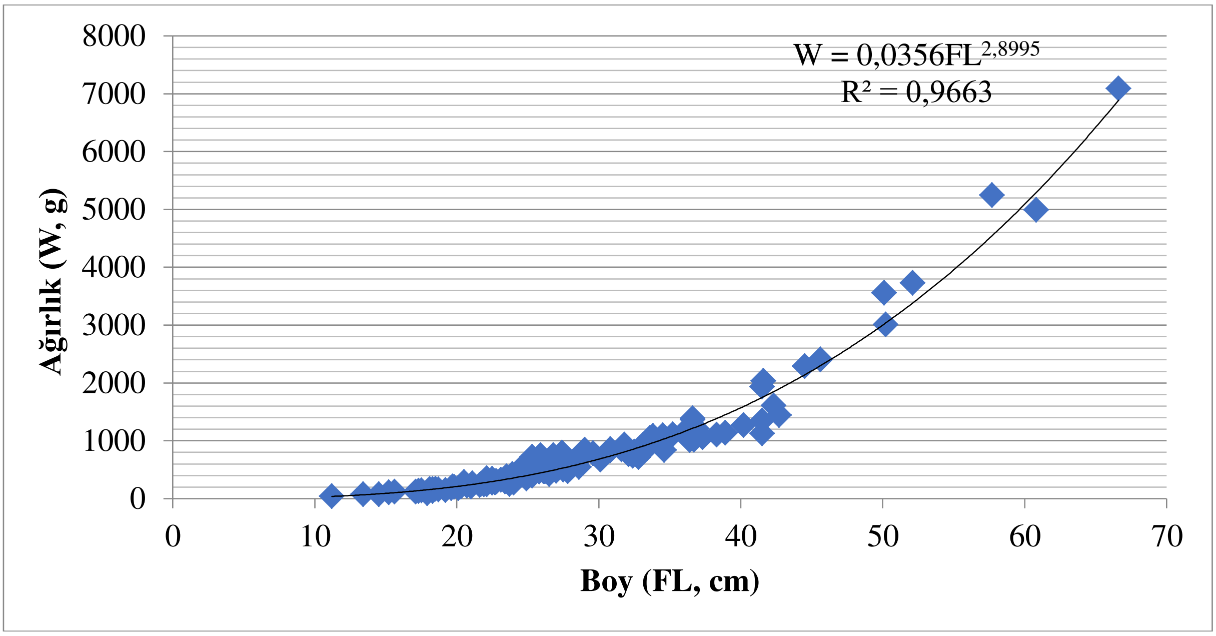
Şekil 7. Oymapınar Baraj Gölü'ndeki tüm *C. carpio* bireylerindeki yaş-ağırlık ilişkisi.

Tablo 2. Oymapınar Baraj Gölü'ndeki sazan populasuyonunun yaş grupları ve eşeylerine göre ortalama ağırlıkları (W, g), ağırlık artış (W) ve oransal ağırlık artış (OW).

Yaş	Dişi				Erkek				t-test	Dişi + Erkek			
	N	W±SE (min-mak)	W	OW (%)	N	W±SE (min-mak)	W	OW (%)		N	W±SE (min-mak)	W	OW (%)
0	3	79,92 ± 5,18 (73,87-90,24)	-	218,38	4	95,60 ± 18,13 (41,73-117,74)	-	156,18	0,400 p<0,05	7	88,88 ± 10,38 (41,73-117,74)	-	182,17
I	21	254,45 ± 28,56 (132,41-517,34)	203	79,77	13	244,91 ± 21,83 (130,97-353,64)	104,94	42,84	0,675 p<0,05	34	250,80 ± 19,29 (130,97-517,34)	163,02	65
II	19	457,59 ± 37,28 (221,89-724,11)	360,83	141,8	13	349,85 ± 23,04 (235,06-479,27)	386,76	110,55	0,02 p>0,05	32	413,82 ± 25,55 (221,89-724,11)	352,54	85,19
III	8	818,42 ± 22,95 (750,95-925,95)	292,781	35,77	14	736,61 ± 44,49 (459,2-1051,13)	270,47	36,71	0,119 p<0,05	22	766,36 ± 30,29 (459,2-1051,13)	301,45	39,33
IV	7	1110,861 ± 83,89 (842,92-1385,5)	27,78	25	5	1034,66 ± 55,91 (812,1-1109,89)	203,26	19,64	0,432 p<0,05	12	1079,11 ± 53,30 (812,1-1385,5)	122,71	11,37
V	4	1138,64 ± 53,11 (1046,25-1270,67)	794,79	69	8	1237,92 ± 87,06 (1010,02-1606,49)	1196,38	96,64	0,356 p<0,05	12	1201,82 ± 58,56 (1010,02-1606,49)	1132,3	94,21
VI	1	1933,43	---	---	3	2434,3 ± 206,60 (2032,58-3007,9)	1210,3	49,71	---	4	2334,12 ± 188,80 (1933,43-3007,9)	1310,48	56,14
VII	0	---	---	---	2	3644,60 ± 86,65 (3557,95-3731,26)	1598,71	65,67	---	2	3644,60 ± 86,65 (3557,95-3731,26)	1472,3	40,39
VIII	1	4990,5	2099	42,05	1	5243,31	1598,71	43,86	---	2	5116,90 ± 126,40 (4990,5-5243,31)	1972,6	38,55
IX	1	7089,5	---	---	0	---	---	---	---	1	7089,5	---	---
TOPLAM	**65**				**63**					**128**			

3.7. Boy-ağırlık İlişkisi

Örneklenen *C. carpio* popülasyonunun boy-ağırlık ilişkisi denklemi tüm bireylerde W= 0,0356 $FL^{2,8995}$ (R^2= 0,982) şeklinde bulunmuştur (Şekil 8). Popülasyon için hesaplanan b değerinin 3'ten küçük olması, büyümenin negatif allometri gösterdiğini belirtmektedir.



Şekil 8. Oymapınar Baraj Gölü'ndeki tüm *C. carpio* bireylerinin boy-ağırlık ilişkisi.

3.8. Kondisyon Faktörü

C. carpio örneklerinin her bir yaş grubu için hesaplanmış ortalama kondisyon faktörü değerleri Tablo 3'te verilmiştir. KF değerleri, dişilerde 1,57 ile 4,32 ve erkeklerde 1,85 ile 4,45 arasında olup, tüm bireylerde ise 1,57 ile 4,45 arasında değişim göstermiştir.

Tablo 6. Oymapınar Baraj Gölü'ndeki sazan popülasyonunun eşey ve yaşa göre hesaplanan kondisyon faktörleri.

Yaş	Dişi		Erkek		Dişi + Erkek	
	N	KF ± SE (min- mak)	N	KF ± SE (min- mak)	N	KF ± SE (min- mak)
0	3	2,37 ± 0,34 (1,57-3,07)	4	2,85 ± 0,16 (2,32-3,10)	7	2,65 ± 0,21 (1,57-3,10)
I	21	2,46 ± 0,05 (1,87-2,81)	13	2,53 ± 0,07 (2,21-3,27)	34	2,49 ± 0,04 (1,87-3,27)
II	19	2,62 ± 0,07 (2,02-3,32)	13	2,41 ± 0,09 (1,97-3,04)	32	2,54 ± 0,05 (1,97-3,32)
III	8	2,94 ± 0,23 (2,02-4,32)	14	3,26 ± 0,17 (2,16-4,45)	22	3,14 ± 0,14 (2,02-4,45)
IV	7	2,38 ± 0,12 (1,57-2,82)	5	2,59 ± 0,16 (2,36-2,80)	12	2,47 ± 0,09 (1,57-2,82)
V	4	2,09 ± 0,10 (1,95-2,20)	8	1,98 ± 0,06 (1,85-2,12)	12	2,05 ± 0,05 (1,85-2,50)
VI	1	2,7	3	2,58 ± 0,09 (2,37-2,82)	4	2,60 ± 0,07 (2,37-2,82)
VII	---	---	2	2,73 ± 0,09 (2,63-2,82)	2	2,73 ± 0,09 (2,63-2,82)
VIII	1	2,22	1	2,72	2	2,72
IX	1	2,39		---	1	2,39
Toplam	**65**	**2,54 ± 0,05**	**63**	**2,65 ± 0,06**	**128**	**2,59 ± 0,04**

4. TARTIŞMA

Oymapınar Baraj Gölü'nde yapılan bu çalışmada, yakalanan *C. carpio* örnekleri 0 - IX yaş aralığında dağılım göstermiştir. I. ve II. yaş grupları % 50,8'lik bir oranla popülasyonun çoğunluğunu oluşturmuştur. Dişilerde en yüksek yaş IX, erkeklerde ise VIII olarak bulunmuştur. Eşey oranlarına bakıldığında dişi bireylerin (%50,8), erkek bireylerden (% 49,2) az da olsa daha fazla oranda bulunduğu görülmüştür.

Oymapınar Baraj Gölü'nde yapılan bu çalışmada, yakalanan bireylerin 0-IX yaş aralığında olduğu tespit edilmiştir. Akşehir Gölü'nde *C. carpio* üzerine yapılan çalışmada yaşlar I-XI arasında değişmiştir (Çetinkaya, 1989). Kırankaya (2001) Gelingüllü Baraj Gölü'nde yaptığı araştırmada *C. carpio* bireylerinin yaş aralığını I - V olarak belirlemiştir. Yılmaz ve Gül, (2002), Hirfanlı Baraj Gölü'nde *C. carpio* bireylerinin yaş aralığını I - IX olarak; Kılıç (2003), Yeniçağa Gölü'nde I - XIV ve Kırankaya (2007) ise, Gelingüllü Baraj Gölü'nde 0 - IX arasında olduğunu bulmuşlardır. Güç (2006), Keban Baraj Gölü'nde yaptığı araştırmada yaş dağılımını I – VII olarak tespit etmiştir. Çalta vd., (2018) ise aynı baraj gölünde yaş dağılımını II-VIII arasında bulmuştur. Oymapınar Baraj Gölü'nde yapılan bu araştırmanın bulguları ile diğer çalışmaların sonuçları karşılaştırıldığında, yaş dağılımının farklı olduğu görülmektedir. Popülasyonda genç bireylerin daha baskın olması, gölde av baskısının olduğunu göstermektedir. Avcılıkta kullanılan av araçlarının seçicilikleri, popülasyonun büyüme hızı, avcılık etkinliği ve gölün ekolojik yapısı yaş dağılımı etkileyen faktörler arasındadır (Baluyut, 1989).

Oymapınar Baraj Gölü *C. carpio* popülasyonunun çatal boylarının 11,2 cm ile 66,6 cm arasında dağılımı gösterdiği belirlenmiştir. Erkek bireylerin çatal boyları 11,2- 57,7 cm arasında, dişi bireylerin ise 13,4- 66,6 cm arasında değişim göstermiştir. İncelenen örneklerin çoğunluğunu oluşturan 22-36 cm ortalama boy grubundaki bireylerin eşeysel olgunluğa ulaşmadığı tespit edilmiştir. Bu nedenle göldeki sazan popülasyonunun varlığını sürdürebilmesi için 36 cm'den daha küçük bireylerin avlanılmaması gerekmektedir.

Kırankaya & Ekmekçi (2004), Gelingüllü Baraj Gölü'nde yaptıkları çalışmada sazan bireylerinin çatal boylarının 11,7 cm ile 63,8 cm arasında değiştiğini tespit etmişlerdir. Çolakoğlu & Akyurt (2011), Bayramiç Baraj Gölü'nde *C. carpio* bireylerinin çatal boylarını 12,8 - 47,9 cm olarak belirlemişlerdir. Erkek bireylerin 13,1 - 42,5 cm arasında olduğunu, dişi bireylerin ise 12,8 - 47,9 cm arasında dağılım gösterdiğini tespit etmişlerdir. Mert (2002) Apa Baraj Gölü'nde yaşayan *C. carpio* bireylerinin ortalama çatal boylarının 15,4 – 50,9 cm arasında olduğunu; Çalta vd., (2018) Keban Baraj Gölü'nde *C. carpio* bireylerinin total boylarını 21,50- 37,50 cm olarak bulmuşlardır. Gelingüllü Baraj Gölü (Kırankaya, 2001, 2007), Yeniçağa Gölü (Kılıç, 2003) ve Keban Baraj Gölü (Güç, 2006; Çalta vd., 2018) *C. carpio* popülasyonlarında yaşlara göre elde edilen boy ortalamaları; Oymapınar Baraj Gölü için elde edilen boy değerlerinden daha büyük olduğu görülmüştür.

Bu çalışmada incelenen *C. carpio* bireylerinin vücut ağırlıkları 41,73 g ile 7.089,5 g arasında değişim göstermiştir. Keban Baraj Gölü'nde *C. carpio* bireylerinin ağırlık değerleri 1,158,3 g ile 10,600 g arasında dağılım gösterdiği saptanmıştır (Güç, 2006). Aynı gölde yapılan bir diğer çalışmada ise örneklerin vücut ağırlıklarının 172,66 g ile 789,17 g arasında değiştiği tespit edilmiştir (Çalta vd., 2018). Yeniçağa Gölü'nde sazan bireylerinin ağırlık değerleri 188 g ile 7797,5 g arasında (Kılıç, 2003), Gelingüllü Baraj Gölü'nde ise 28,2 g ile 8836 g arasında değişim göstermiştir (Kırankaya, 2007).

Gelingüllü Baraj Gölü (Kırankaya, 2001, 2007) ve Keban Baraj Gölü (Güç 2006) popülasyonlarının yaşlara göre ortalama ağırlıkları, Oymapınar Baraj Gölü popülasyonundan daha fazladır. Sazan bireylerinin Yeniçağa Gölü (Kılıç, 2003) ve Bayramiç Baraj Gölü (Çolakoğlu & Akyurt, 2011) popülasyonlarının ise ortalama vücut ağırlıkları V. yaşa kadar benzerlik göstermektedir. Diğer çalışmalardaki ağırlık değerleri, Oymapınar Baraj Gölü'ndeki sazan bireylerinin ağırlık değerlerinden daha düşük olduğu tespit edilmiştir. Popülasyonlar arasında bu farklılıkların ortaya çıkmasında, habitatlardaki iklimsel ve coğrafi farklılıkların yanı sıra, baraj göllerinin farklı ontogenetik evrelerde olması da etkili olabilmektedir (Holcik, 1989; Kırankaya & Ekmekçi, 2007).

Oymapınar Baraj Gölü örneklerinin Von Bertalanffy boyca büyüme denklemi ve değişkenleri sırasıyla; L_∞= 90,15, k = 0,076, t_0 = -1,403 şekilde hesaplanmıştır (Tablo 7). Yaş-boy ilişkisi incelendiğinde dişi-erkek toplamı *C. carpio*'nun ulaşabileceği maksimum boy (L_∞), İznik ve Işıklı Gölü (Apaydın Yağcı vd., 2008a, 2008b) ile Atatürk Baraj Gölü (Yüce, 2016)'ne ait değerlerden düşük bulunmuştur. Nazik Gölü (Şen, 2001) için bulunan L_∞ değerleri bu çalışmaya yakındır.

İncelenen *C. carpio* populasyonunda boy-ağırlık ilişkisini belirleyen regresyon katsayısı olan b değeri 2,89 olarak bulunmuştur. Buna göre *C. carpio*'nun Oymapınar Baraj Gölü'ndeki populasyonlarının negatif allometrik büyüme gösterdiği ifade edilebilir. Sonuç olarak diğer çalışmalardan elde edilen "b" değerleri ile uyumlu olduğu görülmektedir (Tablo 7).

İncelenen dişi, erkek ve tüm *C. carpio* bireylerinin ortalama KF değerleri sırasıyla 2,54, 2,65 ve 2,59 olarak hesaplanmıştır. Tablo 7'de de görüldüğü gibi farklı bölgelerde yapılan çalışmalarda *C. carpio*'nun KF değerlerinin, bu çalışmadaki değerlerden daha düşük olduğu görülmektedir. Kondisyon faktöründeki farklılık, tür içinde yaşa, cinsiyete, cinsel olgunluk durumuna, mevsime, habitata, üremeye, besin zenginliğine ve beslenme şartlarına göre değişim göstermesinden kaynaklanabilir (Ünver & Tanyolaç 1999; Çetinkaya vd., 2010). Tespit edilen kondisyon faktörü değerleri *C. carpio* popülasyonu için Oymapınar Baraj Gölü'nün besleyici bir rezervuar olduğunu göstermektedir.

Bu çalışmada hesaplanan Munro'nun Fi Üssü (Ǿ) değerleriyle, farklı stoklardan elde edilen değerler karşılaştırılmıştır. Oymapınar Baraj Gölü'ndeki örneklerin Seyhan Baraj Gölü (Özyurt & Avşar, 2001) ve Almus Baraj Gölü (Karataş vd., 2005)'ndeki *C. carpio'*nun büyüme performanslarından daha yüksek olduğu bulunmuştur. Aradaki farkın t testine göre önemsiz olduğu saptanmıştır ($p > 0,05$).

Tablo 7. Oymapınar Baraj Gölü'ndeki sazan popülasyonunun L_∞, KF, k, t_0, a,b ve fi üssü (Ǿ) değerlerinin diğer çalışma sonuçları ile karşılaştırılması.

Bölge	**Kaynak**	**Eşey**	**N**	**L_∞**	**KF**	**k**	**t_o**	**a**	**b**	**Ǿ**
Bafra Balık Gölü (Samsun)	Bircan (1993)	♂♂+♀♀	634	77,487	1,86	0,1167	-1,0552	0,024	2,962	2,8455
Gölhisar Gölü (Burdur)	Alp & Balık (2000)	♂♂+♀♀	693	72,76	1,57	0,1723	-0,4456			2,9600
Seyhan Baraj Gölü (Adana)	Özyurt & Avşar (2001)	♂♂+♀♀	257	64,43	1,55	0,115	-1,862			2,6788
Nazik Gölü Bitlis (Bitlis)	Şen (2001)	♂♂+♀♀	801	100	2,66	0,085	-0,46			2,9294
Almus Baraj Gölü (Tokat)	Karataş vd. (2005)	♂♂+♀♀	307	46,39	1,34	0,153	-1,922			2,5175
Beyşehir Gölü (Konya)	Çetinkaya vd. (2006)	♂♂+♀♀	321	82,12		0,1056	-0,7861			2,8525
İznik Gölü (Bursa)	Apaydın Yağcı vd. (2008)	♂♂+♀♀	119	123,5	1,97	0,0895	-0,37			3,1351
Işıklı Gölü (Denizli)	Apaydın Yağcı vd. (2008a)	♂♂+♀♀	158	108,4		0,101	-0,221	0,035	2,841	3,0743
Bafra Balık Gölü (Samsun)	Yılmaz vd. (2012)	♂♂+♀♀	155	60,96	1,86	0,274	-0,802			3,0078
Atatürk Baraj Gölü (Adıyaman)	Yüce (2016)	♂♂+♀♀	231	111,01	1,84	0,06	-1,48			2,8688
Keban Baraj Gölü (Elazığ)	Çalta vd. (2018)	♂♂+♀♀	120	43,09	1,62	0,176	-2,423	0,014	3,040	2,51
Oymapınar Baraj Gölü (Antalya)	**Bu çalışma**	♂♂+♀♀	128	90,15	2,59	0,076	-1,403	0,0356	2,89	2,7907

5. SONUÇ

Bu araştırma Oymapınar Baraj Gölü'nde bulunan ve ekonomik değeri yüksek olan *C. carpio* popülasyonunun biyolojisi üzerine yapılan ilk araştırma olması açısından önem arz etmektedir. Sucul ekosistemlerde balık popülasyonları üzerine yapılan biyolojik ve ekolojik çalışmalar, popülasyonların sürdürülebilirliği ve diğer balık türleri ile olan etkileşimlerinin değerlendirilmesine katkı sağlayacaktır. Çalışmada populasyonunun çoğunluğunu genç bireylerin oluşturduğu tespit edilmiştir. Bu durum yoğun bir av baskısı altında olduğunu göstermektedir. Gölde denetimin artırılması ve kaçak avcılığın önüne geçilmesi popülasyonun kendini yenileyerek dengeli bir dağılım göstermesini sağlayacaktır. Av baskısının ortadan kaldırılması balıkların üremesine olanak verecektir. Gelecek yıllarda avcılığa açılması ile söz konusu türden ekonomik kazanç sağlanabileceği düşünülmektedir.

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Research Article | **Araştırma Makalesi**

Growth Performance and Survival Rate of *Pontastacus leptodactylus* Juveniles Fed with Fresh Black Soldier Fly *Hermetia illucens* and Mealworm *Tenebrio molitor* Larvae

Asker Sineği *Hermetia illucens* ve Un Kurdu *Tenebrio molitor* Larvaları İle Beslenen *Pontastacus leptodactylus* Ergenlerinin Büyüme Performansı ve Yaşama Oranı

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Abstract: In this study, the survival rate and growth performance of crayfish *Pontastacus leptodactylus* juveniles were evaluated when fed with five different diets. These diets were CF: commercial feed, Hİ: Fresh *Hermetia illucens,* CF+Hİ; 50% commercial feed + 50% fresh *Hermetia illucens*, TM: Fresh *Tenebrio molitor*, CF+TM: 50% commercial feed + 50% fresh *Tenebrio molitor.* The experiments of the present study were carried out for 60 days. The results showed that the survival rate, final body weight (FBW), and weight gain (WG) were negatively correlated with fresh BSF and TM diets. All individuals fed only with BSF and TM diets died on approximately the 30th day of the experiment. The final weight, feed conversion ratio (FCR), molting rate and survival rate of crayfish fed with dietary treatment diets showed significant differences on the 30th day (P < 0.05). The crayfish fed with CF+BSFL and CF+TM diets had similar weight, FCR, molting rate, single cheliped injury with the control group on the 30th day and 60th day. However, the highest survival rate was observed in crayfish fed with CF diet followed by CF+BSFL and CF+TM groups on the 60th day. As a result, TM and BSF diets given fresh alone showed negative effects on growth and survival rates in crayfish larvae. Therefore using just fresh insects in the crayfish juvenile diets is not recommended. By decreasing 50% commercial feeds and using as supplementary feed of TM and BSF larvae can show similar growth as the control group. However, 50% TM supplemented with 50% commercial diets is not recommended due to reduced survival rates. On the other hand, fresh BSF can be given to *P. astacus* larvae after reducing the commercial feed by 50% without affecting the survival rate and growth.

Keywords
- Growth
- *Hermetia illucens*
- *Pontastacus leptodactylus*
- Survival rate
- *Tenebrio molitor*

Özet: Bu çalışmada *Pontastacus leptodactylus* juvenile kerevitinin beş farklı yemle beslenmesi durumunda yaşama oranı ve büyüme performansı değerlendirilmiştir. Deneme grupları; CF: ticari yem, HI: Taze *Hermetia illucens*, CF+Hİ; %50 ticari yem + %50 taze *Hermetia illucens*, TM: Taze *Tenebrio molitor*, CF+TM: %50 ticari yem + %50 taze *Tenebrio molitor*. Denemeler 60 gün sürmüştür. Sonuçlar yaşam oranı, nihai vücut ağırlığı ve ağırlık kazancının taze BSF ve TM beslemenin negatif ilişkili olduğunu göstermiştir. Sadece BSF ve TM ile beslenen tüm bireyler deneyin yaklaşık 30. gününde öldükleri gözlenmiştir. Kerevitlerin deneme sonu canlı ağırlığı, yemden yararlanma oranı, kabuk değiştirme ve yaşama oranı 30. günde gruplar arasında önemli farklılıklar göstermiştir (P < 0,05). CF+BSFL ve CF+TM ile beslenen kerevitlerin ağırlık, FCR, kabuk değiştirme oranı, tek çeliped yaralanması ve kontrol grubu ile 30. gün ve 60. günde benzer olduğu görülmüştür. Ancak en yüksek yaşama oranı CF ile beslenen kerevitlerde gözlenmiş, bu grubu 60.

Anahtar kelimeler
- Büyüme
- *Hermetia illucens*
- *Pontastacus leptodactylus*
- *Tenebrio molitor*
- Yaşama oranı

günde CF+BSFL ve CF+TM grupları takip etmiştir. Sonuç olarak, tek başına taze olarak verilen TM ve BSF besinleri kerevit larvalarında büyüme ve yaşama oranı üzerinde olumsuz sonuçlar göstermiştir. Ticari yemlerin %50 oranında azaltılması ve ek yem olarak kullanılmasıyla TM ve BSF larvaları kontrol grubu ile benzer büyüme gösterebilmektedir. Ancak yaşama oranlarının azalması nedeniyle ticari yemlerde %50 oranında TM eklenmesi önerilmemektedir. Taze BSF, *P. astacus* larvalarına, yaşama oranı ve büyümeyi etkilemeden ticari yemi %50 oranında azaltarak verilebilir.

1. INTRODUCTION

Fishmeal has long been a key component of aquafeeds, but its extensive use has strained natural fish stocks, posing threats to marine ecosystems (Lalander et al., 2015; Mousavi et al., 2020). In response, insects have emerged as a promising alternative protein source. Insects raised on organic waste offer sustainable technology for aquaculture, promoting natural nutrient recycling (Sánchez-Muros et al., 2020). Various insect larvae species boast rich nutritional profiles, delivering essential protein, amino acids, fats, carbohydrates, vitamins, and trace elements (Chen et al., 2009). Moreover, insect-based feeds are imbued with bioactive compounds and chitin, known for their antioxidant, antibacterial, and immunostimulatory properties, potentially bolstering the health and immunity of aquatic species (Li et al., 2017; Motte et al., 2019; Mousavi et al., 2020). Numerous studies have demonstrated the efficacy of black soldier fly (BSF) larvae in enhancing growth in aquaculture, showcasing their potential as a protein source for various aquatic species. Research by Zarantoniello et al. (2023), Chen et al. (2022), Richardson et al. (2021), Mastoraki et al. (2020), Herawati et al. (2019) has specifically highlighted the benefits of BSF larvae in fish farming. Similarly, studies conducted by Foysal et al. (2019), Foysal et al. (2021), Wang et al. (2022) have underscored their positive effects on shrimp growth. Additionally, BSF larvae have shown promise as a feed ingredient for crabs, though specific studies on this aspect may be limited.

P. leptodactylus is a native species of Europe. Populations of this species are at risk in many countries. In Turkiye, populations are also decreasing due to disease risk. Therefore, larval culture has become important. There is no formulated ration developed specifically for crayfish larval culture. Shrimp feeds, trout feeds, daphnia and chironomid larvae are commonly used in larval rearing. In this study, we aimed to investigate how reducing the rate of these feeds and supplementing the ration with fresh insects from the wild would affect growth and development.

2. MATERIALS AND METHODS

2.1. The brood stock and management

Egg-bearing females of *P. leptodactylus* weighing 49.59 ± 12.26 g and total length 12.23 ± 1.48 cm were collected by trapping (mesh size 1.5 cm) from Egirdir Lake in March 2020, Türkiye. The eggs were at Blastosphere Phase (Clada et al., 1987). Broodstock were transported to the laboratory of Egirdir Fisheries Faculty and stocked 25 individual / m^2 in tanks (bottom area 120 x 120cm and volume 720L) with freshwater flow (1.2 L min^{-1}). Pipes 8cm diameter and 14 cm length) were placed to provide shelter in each tank. Broodstock were fed ad-libitum with trout feed (45% protein, 20% lipid), fresh chara, fresh fish and potato once daily at 9 am. Leftover feed and feces were siphoned out every other day before commencement of the next feed. The mean water temperature for broodstock culture was 18 ± 1 ^oC.

2.2. Stage II juvenile culture

The eggs of broodstock hatched until early May 2020 and crayfish reached stage II at the end of May. In the culture of stage II juveniles, initial weight and total length of stage II juveniles were 0.038 ± 0.00 g and 10.60 ± 0.06 mm, respectively. The stage II juveniles were stocked randomly to 22 tanks as 75 individual / m^2 at an indoor facility with recirculation for the production of stage III juveniles. Each tank was 80x50x30 cm dimensions, water volume 88 L. The water flow-rate was adjusted to 0.9 L/min. The water in all tanks was provided through a recirculation system and changed systematically with 1 times fresh water and 9 times system water all day long. The system also had a biological filter. The water temperature of Stage II juvenile culture was constant at 18 ^oC. The stage II juveniles were fed ad libitum with dried chara, wheat bran, *Eisenia foetida, Hermetia illucens* larvae*, Tenebrio molitor* larvae, fish meal, trout feed throughout the period of 32 days. Juveniles were provided with food at the amount 4.3 mg / L-1 in terms of visibility of feed. However, juveniles consumed 50% of the feeds. Live H. *illucens*, T. *molitor* larvae and E. *foetida* were grounded with a blender to a size which they could eat (2-3 mm). All diets were fed once daily at 9 am. Leftover feed and feces were siphoned out every day. At the end of 1 month culture , survival rate for stage II juveniles was 73% with this feeding protocol (Table 1), while it was 12% for stage III juveniles, 88% for stage IV juveniles. The mean weights were 0.116 ± 0.010 g, and 0.066 ± 0.008 g respectively for the stage II and sage III juvenile groups.

Table 1. Feeding protocol of Stage II juvenile.

Stage II Culture days	**Dried Chara**	**Wheat bran**	***Eisenia foetida***	***Hermetia illucens* larvae**	***Tenebrio Molitor* larvae**	**Fish meal**	**Trout feed**
1st day	X	-	-	-	-	-	-
2st day	X	-	-	-	-	-	-
3st day	X	-	-	-	-	-	-
4st day	-	-	X	-	-	-	-
5st day	X	-	X	-	-	-	-
6st day	X	-	X	-		-	-
7st day	X	-	X	-	-	-	-
8st day	X	-	X	-	-	-	-
9st day	X	-	-	X	-	-	-
10st day	-		-	X	-	-	-
11st day	X		X		-	-	-
12st day	X	-	X	-	-	-	-
13st day	X	-	X	-	-	-	-
14st day	-	-	X	-	-	-	-
15st day	X	X	X	-	-	-	-
16st day	-	-	X	-	-	-	-
17st day	-	-	-	-	X	X	-
18st day	-	-	-	-	X	X	-
19st day	-	-	-	-	X	X	-
20st day	-	-	-	-	X	X	-
21st day	-	-	-	-	X	X	-
22st day	-	-	X	X	-	X	-
23st day	X	-	-	-	-	X	-
24st day	-	X	X	-	-	-	-
25st day	-	X	X		-	-	-
26st day	-	X	-	X	-	-	-
27st day	-	-	-	X	-	-	-
28st day	-	-	-	X	-	-	X
29st day	X	-	-	X	-	-	X
30st day	-	-	-	X	-	-	X
31st day	-	-	-	X	-	-	X
32st day	-	-	X	-	-	-	X

2.2. Stage III-IV Juvenile Culture

The effects of 5 different diets on *juveniles* of *P. leptodactylus* were researched in this study. The stage III juveniles were stocked randomly to the tanks as 40 individual /m^2 at the same indoor facility as described above in broodstock culture. The stock ratio in stage *III-IV* was reduced due to cannibalism and loss of cheliped in stage II. Live *H. illucens* and *T. molitor* larvae were grounded with a blender to a size which they could eat (3-4 mm). The commercial feed size was 1,5 mm. All diets were fed once daily at 9 am. The stage III juveniles fed 5% of their body weight. CF, BSFL, TM, 50:50 CF: BSFL, 50:50 CF:TM.

2.3. Preparation and Proximate Composition of *Hermetia illucens* and *Tenebrio Molitor* Larvae

Hermetia illucens larvae were obtained, and 0.5-1 cm size larvae were reared on kitchen (all kinds of meal and vegetable waste, bread) waste substrate, from Profatfood Food Feed Industry Co., Ltd. Afyonkarahisar/Türkiye. We fed larvae until they reached 1.5-2 cm in size with animal and vegetable kitchen waste in laboratory conditions. *Tenebrio molitor* larvae were purchased when they were 1-1.5 cm size larvae from Mira Live Animal İnsect, Agriculture Commerce Co., Ltd. Antalya/Türkiye. *T. molitor* larvae were fed with wheat bran, bread, corn, apple, carrot (for water need) until they reached 1.5-2 cm size laboratory conditions (Figure1).

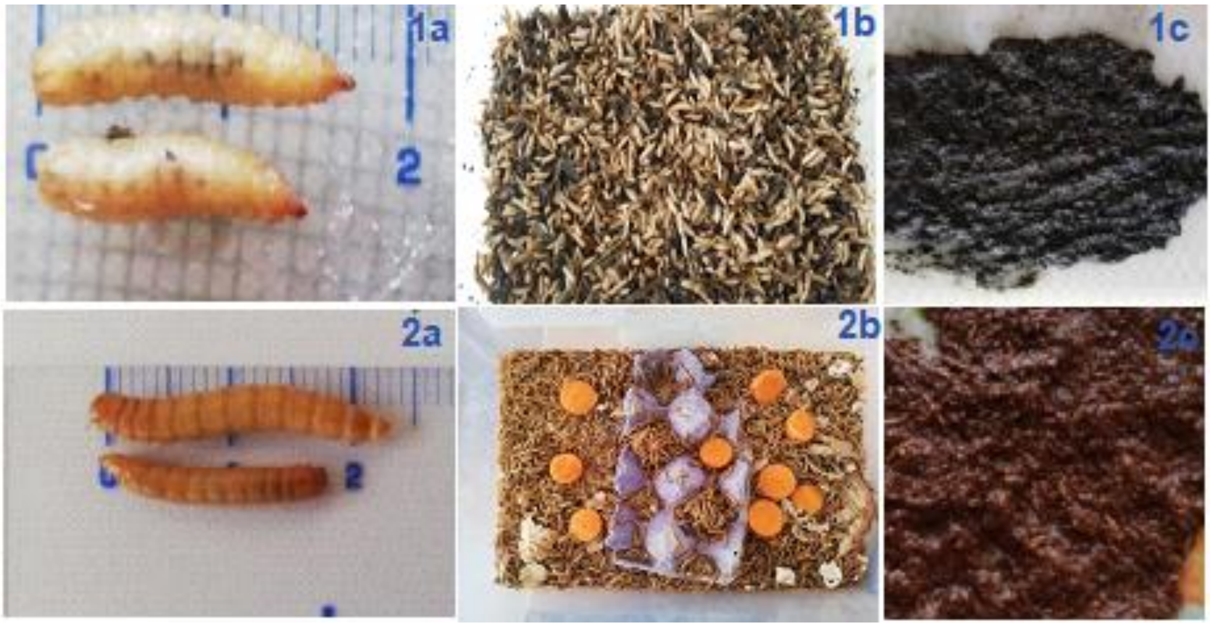

Figure 1. Fresh feeds, 1a; *H. illucens*, 1b; culture conditions of *H. illucens*, 1c; minced *H. illucens*, 2a; T. *molitor* 2b; culture condition of *T. molitor* 2c; minced T. *molitor*

The commercial and fresh feeds, used in this study, were given in the proximate composition as described in Table 2.

The analyses of experimental diets included the determination of dry matter, ash content, crude protein, ether extract according to AOAC (Association of Official Analytical Chemists) manual from 2004 in Egirdir Fisheries Faculty Laboratories. The commercial feed ingredients were fishmeal, fish oil, yeast products, wheat meal, wheat gluten, lecithin, monocalcium phosphate.

Table 2. Proximate compositions of experiment diets.

Based on dry weight (%)	CF	TM	BSFL
Crude protein	56.86	44.45	43.47
Crude lipid	15	33,19	37,73
Crude fiber	0.2	-	-
Ash	13.30	4.51	8.12
Moisture	9.33	38.84	43
Gross energy (Mj/kg)	21.9	26.67	26.94

CF: Commercial feed; TM: minced *T. molitor*; BSFL: minced *H. illucens*
Gross energy (Mj/kg)=(Protein x 0,236)+(Lipid x 0,395)+(Carbohydrate x 0,172)
Carbohydrates (%) = 100- (Protein + Lipid+ Ash)

2.3. Growth parameters

At the end of the experiment, a precision balance was used to measure the weights of crayfish subjects. A ruler was used for the measurement of the total length values. Growth parameters in the experiment were determined using the following formulas (Yu et al., 2020; Mazlum and Uzun, 2022).

Weight gain (WG) g = (final body weight (g) - initial body weight (g))

Specific growth rate (SGR) % = (ln final body weight - ln initial body weight) / experiment days x 100

Survival ratio (%) = (Nt/Nt-1) x 100

Nt = The number of crayfish at the end of the trial

Nt-1= The number of crayfish at the beginning of the trial

Single cheliped injury rate at the end of the trial (%) = 100 x (Single cheliped injury crayfish numbers / The number of crayfish)

Moulting rate (%) = 100 x Moulting number / total crayfish number)

Feed conversion ratio (FCR)= feed consumption (g) /body weight gain (g)

2.4. Statistical analysis

The significance of differences among the experimental groups was tested by one-way analysis of variance (ANOVA). All data were calculated using the IBM SPSS Statistics ver. 20 software (IBM. Armonk. NY. USA). Duncan's test was used to determine the growth differences among treatment means ($P < 0.05$).

3. RESULTS

3.1. Growth performance

The growth performance of crayfish fed with 5 different diets were given in Table 3. The final weight, FCR, molting rate and survival rate of crayfish fed with dietary treatment diets were determined to have significant differences on the 30th day ($P < 0.05$). The crayfish fed with TM and BSFL diets died at the end of 1 month. The crayfish fed with CF+BSFL and CF+TM diets had similar weight, FCR, molting rate and single cheliped injury, with the control group on the 30th day and 60th day. However, the highest survival rate was observed in crayfish fed with CF diet, CF+BSFL and CF+TM groups followed this group on the 60th day.

Table 3. Growth parameters of *juveniles* of *P. leptodactylus* fed with different experimental diets.

	CF	TM	CF+TM	BSF	CF+BSF
1th day Weight (g)	0.066 ± 0.008	0.066 ± 0.008	0.066 ± 0.008	0.066 ± 0.008	0.066 ± 0.008
30th day Length (cm)	2.08±0.03a	1.76±0.02c	2.05±0.03a	1.72±0.03c	1.91±0.04b
30th day Weight (g)	0.19±0.01a	0.12±0.00b	0.20±0.01a	0.13±0.01b	0.21±0.01a
30th day Survival rate (%)	96.88±1.80a	82.81±6.93ab	90.63±4.03ab	78.13±5.41b	92.19±5.92ab
30th day Single cheliped injury (%)	3.13±1.80	9.38±5.41	3.13±3.13	0.00±0.00	3.13±1.80
30th day Moulting rate (%)	15.50±2.50ab	9.00±2.12cb	16.50±1.66a	5.75±1.49c	15.50±2.53ab
30th day FCR	1.73±0.06a	3.83±0.24b	1.71±0.14a	4.23±0.19b	1.69±0.05a
60th day Length (cm)	2.64±0.04	-	2.61±0.06	-	2.55±0.06
60th day Weight (g)	0.36±0.02	-	0.35±0.02	-	0.35±0.02
60th day Survival rate (%)	91.67±4.17a	0	52.08±7.51b	0	70.83± 5.51ab
60th day Single cheliped injury (%)	30.05±10.00	-	17.04±11.92	-	11.19±5.65
60th day Moulting rate (%)	37.66±2.40	-	32.00±2.51	-	32.66±3.88
60th day FCR	1.33±0.17	-	1.47±0.17	-	1.37±0.12

Mean values with different superscripts in the same line are significantly different at $p < 0.05$.

4. DISCUSSION

At the end of this study, feeding fresh TM and BSF larvae to the crayfish suppressed the growth compared to other groups by the 30th day. By the end of the 60th day, there were no live crayfish left in these groups. The CF, CF+TM, and CF+BSF groups showed similar growth, but their survival rates decreased in the order of CF> CF+TM> CF+BSF. Similarly, He et al. (2022), found the best growth in *L.vannamei* fed with diet 75% commercial feed + 25% fresh BSFL. Muslimin et al. (2023), also reported that when cork fish (*Channa striata*) were fed with certain proportions of commercial feed and fresh BSFL meal, feeding more than 20% BSFL suppressed growth.

Similarly, M. Ordoñez et al. (2022) reported that *Colossoma macropomum* juvenile fed with fresh BSFL (50%) and commercial feed (50 %) had similar growth to that of fed with commercial fish feed. The worst growth was observed in the group fed with fresh BSFL. In crustaceans, He et al. (2022) determined that survival rate, final body weight, and weight gain were negatively affected when the amount of fresh BSFL was increased more than 50 % in the diet of L. *vannamei. To the best of our knowledge* there is no other reported study where BSFL were given freshly to crustaceans. We think that chitin containing diets negatively affect the growth of crayfish juveniles since their digestible system has not developed sufficiently to utilize chitin yet. Chitin on the outside of the insect larva, suppressing growth, is seen as a problem in fresh or processed products. Kroeckel et al. (2012), reported that chitin impaired the digestibility of crude protein. Bad smell was another disadvantage for fresh feeds.

Follow-up studies involved adding them to diets in flour form. Chen et al. (2022), reported a decreased growth performance of *Litopenaeus vannamei* fed with BSF meal diet with 30% replacement protein of fishmeal compared to the control (containing 25% fish meal). Richardson et al. (2021), found that 10.5% BSF in the diets of *L. vannemi* fry improved weight gain, feed conversion, and SGR (containing 15% fishmeal). Herawati et al. (2019), determined the best growth support in *L. vannamei* fry fed diet containing 16% BSF instead of fish meal (control contained 32% fish meal). Mastoraki et al. (2020), reported the best growth on fishmeal-based diet in shrimp *Palaemon adspersus* fed diets containing BSF+ soybeans and BSF+ Fishmeal (control contains 26% fishmeal). Foysal et al. (2019), observed similar growth between a diet composed of poultry byproducts + black soldier fly (BSF) larvae compared to a fishmeal diet in crayfish *Cherax cainii*. Wang et al. (2022), reported that the optimal nutritional status of FM for juvenile *Cherax quadricarinatus* was determined to be 21.9% and 17.1% of fish meal with TM and BSFL (black soldier fly larvae) meal. Replacing fishmeal with 50% TM in the diet of *P. leptodactylus* fry improved the comparative growth performance of the control diet containing 27% fishmeal (Mazlum et al., 2021). Similarly, Choi et al. (2018), stated that replacing fishmeal with 50% TM in the diet is optimal for growth support. Cai et al. (2022), reported that replacing 60 g/kg fish meal with TM reduced growth performance and nutrient utilization of *L. vannamei*. Feng et al. (2019), noted that the best growth was detected in *L. vannamei* fed with dietary inclusion of 12% TM among all groups.

Differences in studies may be due to different protein, lipid, and chitin levels of the BSFL and TM, also use of fresh or processed products. In addition, the feeding duration in the studies and fish meal levels in the control diets may affect the results.

As a result, TM and BSF diets given fresh alone showed negative results on growth and survival rate in crayfish larvae. Therefore using just fresh insects in the crayfish juvenile diets is not recommended. By decreasing 50% commercial feeds and using as a supplementary feed of TM and BSF larvae can show similar growth as the control group. However, supplemented 50 % rate TM to commercial diets cannot be recommended due to reduced survival rates. Fresh BSFL can be given to *P. astacus* larvae by reducing commercial feed by 50% without affecting the survival rate and growth.

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CONFLİCT OF INTEREST

The authors declare that they have no financial interests or personal relationships that could influence this work.

ETHİCAL STATEMENTS

Local Ethics Committee Approval was not obtained because experimental invertebrate animals were used in this study.

DATA AVAİLABİLİTY STATEMENT

The data used in this study are available from the corresponding author upon reasonable request.

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Research Article **Araştırma Makalesi**

Kocaavşar Deresi (Balıkesir)'nde *Unio bruguierianus* (Bourguignat, 1853) ve *Unio pictorum* (Linnaeus, 1758) Türlerinin İlk Kaydı ve Bazı Biyometrik Özellikleri

First Record of *Unio bruguierianus* (Bourguignat, 1853) and *Unio pictorum* (Linnaeus, 1758) Species in Kocaavşar Stream (Balıkesir) and Some Biometric Characteristics of These Species

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Özet: Bu çalışmada, Kocaavşar Deresi (Balıkesir)'nde (39°40'22"-27°35'34" Kuzey/Doğu) tatlı su midyeleri *Unio bruguierianus* ve *Unio pictorum*'un yaşadığı tespit edilmiştir. Ayrıca bu türlerin bazı biyometrik özelliklerini tanımlanmıştır. Bireylerdeki ağırlık (A) (g), kabuk uzunluğu (KU) (mm), kabuk genişliği (KG) (mm) ve kabuk yüksekliği (KY) ölçümleri yapılmıştır. Morfolojik ilişkiler, çok değişkenli istatistiksel analizlerle incelenmiştir. *U. pictorum* ve *U. bruguierianus*'un KU, KG, KY ve A ortalamaları sırasıyla şunlardır: 58,20±13,91 ve 75,34±8,08 mm (KU), 29,52±6,93 ve 39,89±7,04 mm (KG), 19,38±4,66 ve 26,33±3,79 mm (KY) ve 25,72±13,56 ve 46,15±9,59 g (A). Temel bileşenler analizi (TBA), her iki tür için KU, KG, KY ve A arasında kuvvetli bir ilişki olduğunu göstermiştir.

Anahtar kelimeler
- *Unio bruguierianus*
- *Unio pictorum*
- Tatlısu midyesi
- Biyometrik Özellikler
- Kocaavşar Deresi

Abstract: In the present study, it is determined that freshwater mussels *Unio bruguierianus* and *Unio pictorum* live in Kocaavşar Stream (Balıkesir) (39°40'22"-27°35'34" North/East). Additionally, some biometric features of these species have been described. Weight (A) (g), shell length (KU) (mm), shell width (KG) (mm) and shell height (KY) of the individuals were measured. Morphological relationships were examined by multivariate statistical analyses. The means of SL, SH, SW and W of *U. pictorum* and *U. bruguierianus* are 58.20±13.91 and 75.34±8.08 mm (SL), 29.52±6.93 and 39, 89±7.04 mm (SH), 19.38±4.66 and 26.33±3.79 mm (SW), and 25.72±13.56 and 46.15±9.59 g (W), respectively. Principal component analysis (PCA) showed a strong relationship between SL, SH, SW and W for both species.

Keywords
- *Unio bruguierianus*
- *Unio pictorum*
- Freshwater mussel
- Biometric characteristics
- Kocaavşar Stream

1. GİRİŞ

Unionida ordosuna ait tatlı su midyeleri, sucul ekosistemlerin önemli bir parçasıdır (Şereflişan

2003, 2008; Lopes-Lima vd., 2021). Benzersiz yaşam döngüleri (kuluçka, balıklar üzerinde larval parazitizm) ile sucul ekosistemlerin önemli bileşenleridir (Sereflisan, 2018; Gürlek, 2023). Bu canlılar, zaman zaman bentik biyokütlenin %90'ından fazlasını oluşturabilirler. Mcivor (2004) tatlı su midyelerinin saatte yarım litreye kadar su filtre edebildiklerini bildirmiştir. Kabukları, diğer organizmalar için yaşam alanı sağlar. Ayrıca, kabukları yapısal özelliklerinden dolayı bazı malzemelerin üretiminde kullanılabilirken (Kutluyer Kocabaş ve Kocabaş, 2023; Şereflişan, 2023), etleri insanlar ve diğer canlılar için önemli bir protein kaynağı olabilir (Gürlek, 2023).

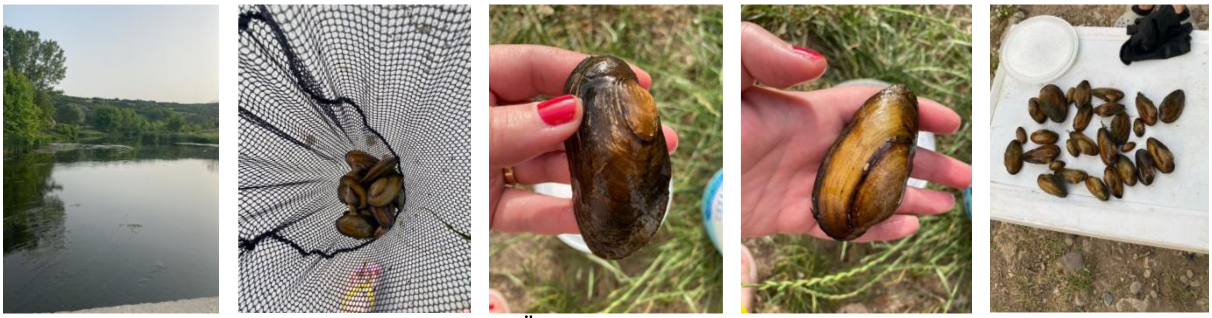
Unio popülasyonları akarsulardan nehirlere, göllerden sulak alanlara kadar çeşitli farklı tatlı su habitatların da dağılım gösterirler (Lopes-Lima vd., 2017). Kabuk morfolojisindeki yüksek derecede tür içi esneklik ve türler arasında teşhis edilebilir kabuk morfolojik karakterlerinin azlığı nedeniyle Unio cinsi içindeki tür sınırlarının belirlenmesi oldukça zordur (Zieritz vd., 2010; Pri'e ve Puillandre, 2014; Klishko vd., 2017). Türkiye'de Unio türlerinin farklı su kaynaklarında dağılımı ve morfolojik özellikleri (Keskinbalta, 2015; Demirci Demirbaş, 2016; Yılmaz ve Barlas, 2016; Küçükyılmaz ve Şahin, 2017; Coşkun vd., 2019; Kocabaş ve Kutluyer Kocabaş, 2021; Kutluyer Kocabaş vd., 2022), büyüme, üreme, yaş, kondisyon ve biyokimyasal parametreleri (Yalçın, 2006; Can ve Şerflişan, 2018; Şereflişan ve Gökçe, 2024), ağır metal birikimi (Türkmen vd., 2005; Şahin vd., 2016), et kalitesi ve kimyasal kompozisyonu (Akyurt ve Erdoğan, 1993; Erdilal ve ark., 2007; Başçınar vd., 2009; Ekin vd., 2009; İşlıyen, 2017) ile ilgili çalışmalar gerçekleştirilmiştir.

Türkiye, tatlı sulak alanlarda en zengin biyolojik çeşitliliğe sahip ülkelerden biridir ve bu alanlarda tehlike altındaki türlerin sayısı ve oranı da diğer ülkelere göre daha yüksektir. Ayrıca, küresel ölçekte, nesli tükenmiş veya kendi ülke sınırları içinde kaybolmuş bazı türlerin sayısı açısından da önde gelen bir ülkedir (Gürlek, 2023). Bu çalışma, Susurluk havzası içerisinde yer alan Kocaavşar Deresi'nde yaşayan *Unio bruguierianus* (Bourguignat, 1853) *ve Unio pictorum* (Linnaeus, 1758) popülasyonu ve bazı biyometrik özellikleri ile ilgili ilk bilimsel rapor olma özelliği taşımaktadır.

2. MATERYAL ve METOT

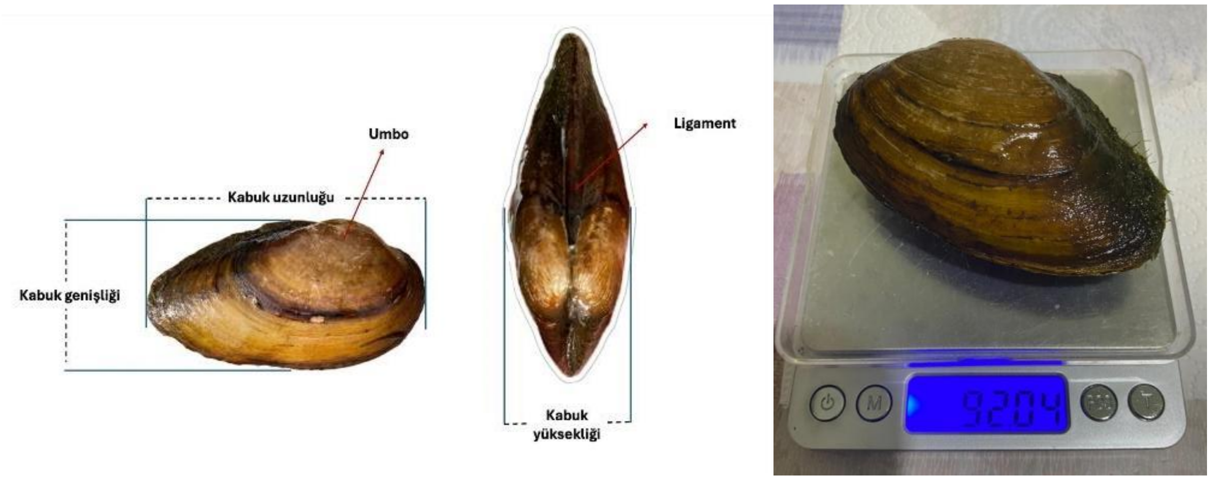
Çalışmada kullanılan *U. bruguierianus* (n: 20) *ve U. pictorum* (n: 10), Nisan-Mayıs 2024 tarihlerinde Kocaavşar Deresi (Balıkesir)'nden (39°40'22"-27°35'34" Kuzey/Doğu) (Şekil 1) toplanmıştır.

Örneklerin toplanmasında, metal çerçeveli kepçeler ve kürekler, dip taranması için tırmık kullanılmış, 20 cm ile 1 m su derinliğine kadar olan kumlu, çakıllı ve taşlı bölgelerden bireyler elle toplanmıştır (Şekil 1) ve örnekler +4°C'de strafor kutularda muhafaza edilmiştir (Yarsan ve ark., 2000). Örnekleme alanında *Squalis* sp., *Alburnus* sp. ve *Vimba* sp. balık türlerinin ve *Carex* sp. su bitkisinin dağılım gösterdiği gözlenmiştir. Toplanan tatlı su midyelerinin teşhis ve tanımlanması literatürde mevcut olan farklı *Unio* türlerinin açıklamaları ve çizimleriyle karşılaştırılarak gerçekleştirilmiştir (Gürlek, 2023). *U. pictorum* kabukları, konveks ve oval şekilli olup, kalın çeperli ve koyu yeşil renkte bir periostrakumla kaplıdır. Kabuklar, bir dorsal ligament ile bağlanır ve açılıp kapanabilir özelliktedir. Arka uçları sivri, umbo ise belirgin ve orta konumdadır. Renk açık kahverengiden koyu kahverengi tonlarına kadar değişiklik gösterebilir. *Unio bruguierianus* türünde, kabuk yuvarlak şekilli, sert yapılı ve umbo anteriyor uca yakın konumlanmıştır. Renk açık kahverengi tonlarından koyu kahverengiye kadar değişebilir, ancak morfolojik olarak büyük ve uzun bir yapıya sahiptir ve umbo daha belirgin bir yapıdadır (Gürlek, 2023).



Şekil 1. Örneklerin toplanması

Midyelerin kabuk uzunluğu, kapakçığın ön kenarından arka kenarına olan mesafedir, kabuk yüksekliği ise kapakçığın dorsal kenarından ventral kenarına kadar olan mesafedir. Kabuk genişliği, midyenin yatay olarak tutulan iki valfi arasındaki umbo yüksekliği olarak ölçülmüştür. Bu ölçümler 0,05 mm hassasiyete sahip kumpas ile yapılmıştır. Canlı ağırlık alınmadan önce her bir midye numunesi kurutma kağıdı ile kurutulmuş, daha sonra kapakların ön ve arka kapama kasları kesilerek birbirinden ayrılmıştır. Ağırlık ölçümleri ise hassas terazi (±0,001 g) ile gerçekleştirilmiştir (Akkuş ve ark., 2019; Sereflisan ve Gökçe, 2024) (Şekil 2).



Şekil 2. Biyometrik ölçümler; Kabuk uzunluğu (KU), Kabuk genişliği (KG), Kabuk yüksekliği (KY) ve ağırlık (A) (Akkuş ve ark., 2019; Şereflişan ve Gökçe, 2024).

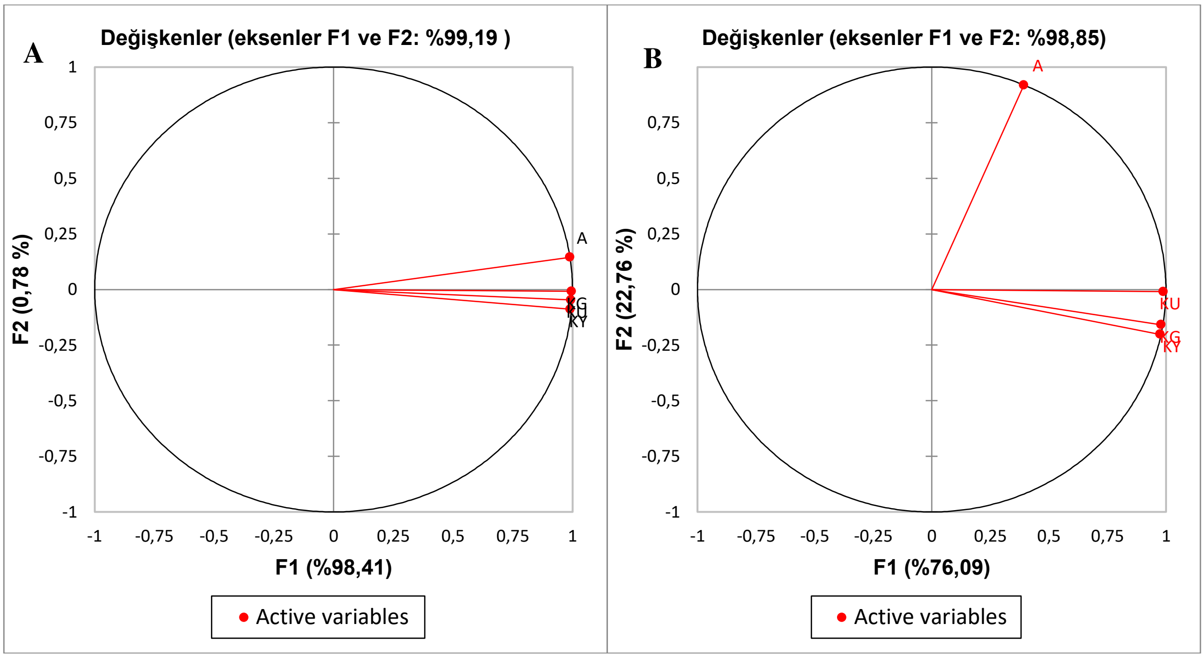
Biyometrik parametreler arasındaki ilişkilerin belirlenmesinde korelasyon analizi ile verilerin analizi ve işlenmesinde Microsoft Excel® kullanılmıştır. TBA'nın yararlılığını değerlendirmek amacıyla Kaiser-Meyer-Olkin örnekleme yeterlilik ölçüsü (KMO) kullanıldı. KMO, 0 ile 1 arasında değişir; değişkenler birbirine yeterince bağımlıysa ve TBA kullanışlıysa 0.5'in üzerindedir. Ayrıca, TBA'nın faydalı olup olmadığını belirlemek için Bartlett testi de uygulanmıştır. Değişkenler arasındaki ilişkilerin belirlenmesinde temel bileşenler analizi (TBA) XLSTAT yazılımı (versiyon 2015.5) kullanılarak uygulanmıştır.

3. BULGULAR ve TARTIŞMA

Tatlı su midyeleri, doğal ortamda %5,9'luk bir yok olma oranıyla en çok tehdit altındaki faunal gruplar arasında yer almaktadır (IPBES 2019; Lopes-Lima ve ark. 2021). Habitat kalitesinde azalma, hidrolojik rejim ve koşullardaki değişiklikler, istilacı/yabancı türlerin yayılması ve son zamanlarda iklim kriziyle bağlantılı kuraklıklar gibi bunların azalmasını etkileyen çeşitli faktörler vardır (Bogan, 1993; Hastie vd., 2003; Nobles ve Zhang, 2011; Moore vd., 2019). Avrupa kökenli bir tür olan *U. pictorum*, ülkemizin Kuzeybatı bölgelerinde (Meriç, Sakarya, Susurluk, Gediz ve Karamenderes nehir havzaları) dağılım gösterirken *U. bruguierianus* türü Yunanistan'dan Trakya'ya, Batı Anadolu'dan Yukarı Dicle, Yukarı Fırat ve Aras havzalarına ve oradan Ermenistan, Azerbaycan ve İran'a kadar dağılım göstermektedir (Gürlek, 2023). Bu çalışma ile Kocaavşar Deresi (Balıkesir)'nde *Unio bruguierianus ve Unio pictorum* türlerinin varlığı ilk defa ortaya konmuştur. Örnekleme alanında iki türe ait birey karışık olarak bulundukları tespit edilmiştir. İki farklı türün aynı ortamda bulunması, beslenme kaynakları, yaşama alanları ile ilgili rekabetin oluşmasına, genetik etkileşimler sonucu hibridizasyona ve gen akışına neden olabilir (Porto-Hannes vd., 2021).

Bu çalışmada, *U. bruguierianus* (Bourguignat, 1853) *ve U. pictorum* (Linnaeus, 1758)'un KU, KG, KY ve A ortalamaları sırasıyla 58,20±13,91 ve 75,34±8,08 mm; 29,52±6,93 ve 39,89±7,04 mm; 19,38±4,66 ve 26,33±3,79 mm; ve 25,72±13,56 ve 46,15±9,59 g olarak belirlenmiştir. Yalçın (2006), *U. pictorum* türünün ortalama ağırlığının 50,37±1,89 g ve kabuk uzunluğunun 83,47±1,16 mm olduğunu belirtmişlerdir. Keskinbalta (2015) ise Sinop İli Karasu Çayı'nda gerçekleştirdikleri çalışmada *U. pictorum* için ortalama kabuk uzunluğunun 55,02±0,16 mm, genişliğinin 27,36±0,08 mm, yüksekliğinin 18,68±0,67 mm ve ağırlığının 20,58±0,27 g olduğunu bildirmişlerdir. Gürlek vd. (2016) Mersin Limonlu (Lamos) Çayı'ndan elde ettikleri *U. bruguierianus* bireylerinde kabuk yüksekliğinin 29,5 ile 36,6 mm arasında değiştiğini bildirmişlerdir. Kocabaş ve Kutluyer (2021) Demirköprü Baraj Gölü'nden elde ettikleri *U. pictorum* popülasyonundaki bireylere ait ortalama kabuk uzunluğu 61.02±7.78 mm (43.02-77.12 mm), kabuk genişliği 32.01±4.48 mm (22.04-40.11 mm), kabuk yüksekliği 17.87±3.43 (10.19-26.07 mm) ve ağırlığı 23.08±2.90 g (17.41-31.39 g) olarak belirlemişlerdir. Bu çalışmadan elde edilen veriler önceki çalışmalarla (Yalçın, 2006; Keskinbalta, 2015; Gürlek vd., 2016; Kocabaş ve Kutluyer, 2021) benzerlik göstermektedir.

Kocabaş ve Kutluyer (2021) Demirköprü Baraj Gölü'ndeki *U. pictorum* popülasyonu ile ilgili yaptıkları çalışmada, Temel bileşenler analizinin (TBA) kullanışlılığını doğrulamak için Bartlett'in testi ve KMO kullanılmışlar ve Temel bileşenler analizinin, korelasyon matrisini özetlemede faydalı (KMO = 0.78) ve Bartlett'in test verileri anlamlı olduğu belirlemişlerdir ($p = 0.000$; $p < .001$). Bu nedenle, temel bileşenler analizi yararlı ve değişkenler birbirleri ile ilişkili olduğunu bildirmişlerdir. Toplam varyansın *U. pictorum* %94.379'luk kısmının iki temel bileşen tarafından açıklanmış olduğu tespit etmişlerdir. Kabuk yüksekliği (KY), Kabuk genişliği (KG), Kabuk uzunluğu (KU) ve Ağırlık (A) arasında güçlü bir ilişki olduğu belirlemişlerdir. Bu çalışmada da benzer olarak, toplam varyansın *U. pictorum* %98,85 ve *U. bruguierianus* %99,19'luk kısmının iki temel bileşen tarafından açıklanmış olduğu, korelasyon matrisini özetlemede faydalı ($KMO_{U.\ pictorum} = 0.66$; $KMO_{U.\ bruguierianus} = 0.88$) ve Bartlett'in test verileri anlamlı olduğu belirlenmiştir ($p = 0.000$; $p < .001$). Bu nedenle, temel bileşenler analizi yararlı ve değişkenler birbirleri ile ilişkili olduğu tespit edilmiştir. Kabuk yüksekliği (KY), kabuk genişliği (KG), kabuk uzunluğu (KU) ve ağırlık (A) arasında her iki tür için güçlü bir ilişki olduğu belirlenmiştir (Şekil 3).



Şekil 3. Değişkenlere [Kabuk uzunluğu (KU), Kabuk yüksekliği (KY) ve Kabuk genişliği (KG)] ait temel bileşenler analizi; A) *U. bruguierianus*, B) *U. pictorum.*

Tablo 1. *U. bruguierianus* için ölçülen parametreler arasındaki korelasyon matrisi.

Değişkenler	KU	KG	KY	A
KU	1	0,957	0,960	0,377
KG	0,957	1	0,984	0,242
KY	0,960	0,984	1	0,200
A	0,377	0,242	0,200	1

*Değerler 0'dan farklıdır ve anlamlılık düzeyi alfa=0,95'tir.

Tablo 2. *U. pictorum* için ölçülen parametreler arasındaki korelasyon matrisi.

Değişkenler	KU	KG	KY	A
KU	1	0,989	0,978	0,973
KG	0,989	1	0,981	0,980
KY	0,978	0,981	1	0,970
A	0,973	0,980	0,970	1

*Değerler 0'dan farklıdır ve anlamlılık düzeyi alfa=0,95'tir.

Kocabaş ve Kutluyer (2021) *U. pictorum* türünde, kabuk uzunluğu-kabuk genişliği, kabuk genişliği-ağırlık arasında güçlü korelasyon olduğunu bildirmişlerdir. Bu çalışmada, *U. bruguierianus* türünde, kabuk uzunluğu-kabuk genişliği, kabuk uzunluğu-kabuk yüksekliği, kabuk genişliği-kabuk yüksekliği arasında güçlü bir korelasyon olduğu tespit edilmiştir (Tablo 1). *U. pictorum* türünde ise kabuk uzunluğu-kabuk genişliği, kabuk uzunluğu-kabuk yüksekliği, kabuk uzunluğu-ağırlık, kabuk genişliği-kabuk yüksekliği, kabuk genişliği-ağırlık ve kabuk yüksekliği-ağırlık arasında güçlü bir korelasyon olduğu belirlenmiştir (Tablo 2).

4. SONUÇ

Sonuç olarak, *U. bruguierianus* ve *U. pictorum* örneklerinin Kocaavşar Deresi'nde rapor edilmesine ilişkin bu bulgu ile bu türlerin aynı habitatta beraber yaşayabildiği ortaya koyulmuştur.

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Research Article
Araştırma Makalesi

Impacts on Aquatic Life for Indiscriminate Exploitation of Baby Shrimp (*Penaeus monodon*) in the Coastal Area, South-Western Region of Bangladesh

Bangladeş'in Güneybatı Bölgesindeki Kıyı Bölgesinde Yavru Karideslerin (*Penaeus monodon*) Ayrım Gözetmeksizin Tüketilmesinin Su Yaşamı Üzerindeki Etkileri

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Abstract: Baby shrimp (*Penaeus monodon*) post-larvae fishing is a major source of income for the most fishermen in the coastal region of the south-western part of Bangladesh during the whole year. These post-larvae collectors lack financial security and are socially regressive. Other aquatic species are destroyed by the indiscriminate exploitation of baby shrimp for aquaculture. According to the present study, about 98-99% of other larvae are destroyed to catch nearly 1-2% of indiscriminate exploitation baby shrimp in our study area where averagely 0.35% *Penaeus indicus*, 0.06% *Penaeus merguiensis*, 0.037% *Metapenaeus monoceros*, 3.58% other shrimp, 6.59% fin-fish larvae, 5.95% crab larvae, and 82.42% small organisms. Actually, the government of Bangladesh already has declared a ban period and outlawed baby shrimp fishing. However, the poor fishermen are fishing continuously in order to maintain their 's livelihood. Furthermore, because of wild baby shrimp are said to have a far higher survival rate than baby shrimp raised in hatcheries, farmers prefer wild baby shrimp. For thousands of Bangladeshi coastal landless and jobless poor people, wild prawn baby shrimp fishing has created employment opportunities. This study describes the impact of wild baby shrimp fishing in coastal area of Bangladesh.

Keywords
- Baby shrimp
- Indiscriminate
- Exploitation
- Bycatch

Özet: Yavru karides (*Penaeus monodon*) avcılığı, tüm yıl boyunca Bangladeş'in güneybatı kesimindeki kıyı bölgelerindeki çoğu balıkçı için önemli bir gelir kaynağıdır. Bu larva sonrası evredeki yavru toplayıcılar finansal güvenceden yoksunlar ve sosyal durum olarakta gerilemekteler . Diğer su türleri de, yavru karideslerin su ürünleri yetiştiriciliği amacıyla ayrım gözetmeksizin kullanılması nedeniyle yok edilmektedir. Mevcut çalışmamız göstermektedir ki ortalama olarak %0,35'i *Penaeus indicus*, %0,06'sı *Penaeus merguiensis*, %0,037'si *Metapenaeus monoceros*, 3,58'i diğer karides, %6,59'u yüzgeçli balık larvası, %5,95'i yengeç larvası ve %82,42'si küçük organizmalar olmak üzere, araştırma alanımızda gelişigüzel kullanılan yavru karideslerin yaklaşık %1-2'sini yakalamak için diğer larvaların yaklaşık %98-99'u yok edilmektedir. Aslında Bangladeş hükümeti hali

Anahtar kelimeler
- Yavru karides
- Ayrım gözetmeksizin
- İstismar
- Hedef dışı av

hazırda bir yasak dönemi beyan etti ve yavru karides avcılığını yasadışı ilan etti. Ama yoksul balıkçılar geçimlerini sağlamak için avcılığa devam etmektedirler . Ayrıca yabani yavru karideslerin, kuluçkahanelerde yetiştirilen yavru karideslere göre çok daha yüksek hayatta kalma oranına sahip olması sebebiyle , balık çiftçileri yabani yavru karidesleri tercih ediyor. Yabani yavru karides avcılığı, Bangladeş kıyılarındaki binlerce topraksız ve işsiz yoksul insan için istihdam fırsatları yarattı. Bu çalışma, Bangladeş'in kıyı bölgelerinde yabani yavru karides avcılığının etkisini açıklamaktadır.

1. INTRODUCTION

Bangladesh is a land of rivers. Brackish water covering the entire southern section of the country is around 710 kilometers wide (Pramanik, 1988). The south-western districts of this country are Satkhira, Khulna, and Bagerhat. One of the grazers of saline water bodies is marine shrimp. Khulna is even known as the place of white gold for shrimp production. The biodiversity of Bangladesh is very rich in fish, mollusks, crustaceans, and other aquatic animals. 151 genera have been identified from the Bay of Bengal which is a habitat to 442 species of fishes, 36 marine shrimps, and about 336 molluscs (Ahamed et al., 2012). This shrimp collection method has caused significant ecological damage over decades. Bycatch from shrimp fishing is common and can account for as much as 65 percent of all caught fry. The collectors entirely discard this bycatch, which results in a great loss for other aquatic species (Das et al., 2016). The fast growth of commercial shrimp farms, indeed focused on export in the country's coastal regions, has significantly raised the demand for baby shrimp over the last 20–25 years (Ahmed et al., 1998). Although many hatcheries have been established here compared to previous years, local fishermen are still involved in the collection of baby shrimp. Generally, they use destructive fishing gear. According to field observation, they claim that natural baby shrimp are more demandable than hatcheries because of their quality and they have no alternative income sources. Since the 1970s, shrimp fry harvesting has expanded in potential as a substitute occupation for the marginal farmers' means of subsistence along Khulna's southwest coastal zone (Mahmood & Ansary,2013). Shrimp farming provided a significant early economic return, expanded rapidly, and quickly developed into a multibillion-dollar business. Large-scale hatchery productions are a possible source of coastal pollution even though hatcheries were developed as a viable alternative and mostly replaced the natural seed source (Islam et al., 2004). In Bangladesh's coastal regions, the interaction between human societies and the environment in this area is highly noticeable. Management of coastal resources has become crucial and essential for reasons related to nutrition, the economy, and the environment (Bergin & Michaelis, 1996). Currently, one of the most significant areas of the national economy is fish farming. Due to its export potential, its development has received a lot of attention during the past 20 years. As a result, a sizable region along the coasts of Khulna, Satkhira, and Bagherhat has been transformed into a prawn farm. The giant freshwater shrimp *Macrobrachium rosenbergii* and the black tiger prawn *Penaeus monodon* are the two species that are most commonly cultivated for their rapid growth in Bangladesh (Ahmed, 2000; DOF, 2002). This study will focus on the extent of damage to shrimp fry by illegal fishing along with other fish fry.

2. MATERIALS AND METHODS

The sampling station in the coastal region of Bangladesh was selected for a preliminary investigation based on the availability of shrimp and fish larvae and other aquatic animals. The present study was performed in the coastal rivers and seashore part of the Khulna region from July 2022 to June 2023. Monthly interval sampling was done using a rectangular drag net of nylon netting (mesh size 0.3 mm) and bamboo split structure (1.6×0.6 m) of Fixed Bag Net (FBN) and Push Net (PN). Samples were taken in the course of full-moon and new-moon. The net was operated in the shallow water of the beach. Each hauling time was 60 minutes. Two samples were collected at the time during low and high tides. The net was tilted three times at each station. Samples were immediately stored in a 250 mL plastic pot and preserved in 5% formalin (45% formaldehyde) after collection for sorting shrimp PL, larvae of fin fishes, shellfish (example), and other organisms. Then, the samples were taken to the Khulna Agricultural University (KAU) laboratory for quantitative and qualitative analysis. Shrimp larvae were identified up to order/species level and macro-zooplankters including fin fishes and other aquatic species were identified. Data were entered and analyzed using the Excel program (Microsoft Office 2020) and statistical analyses.

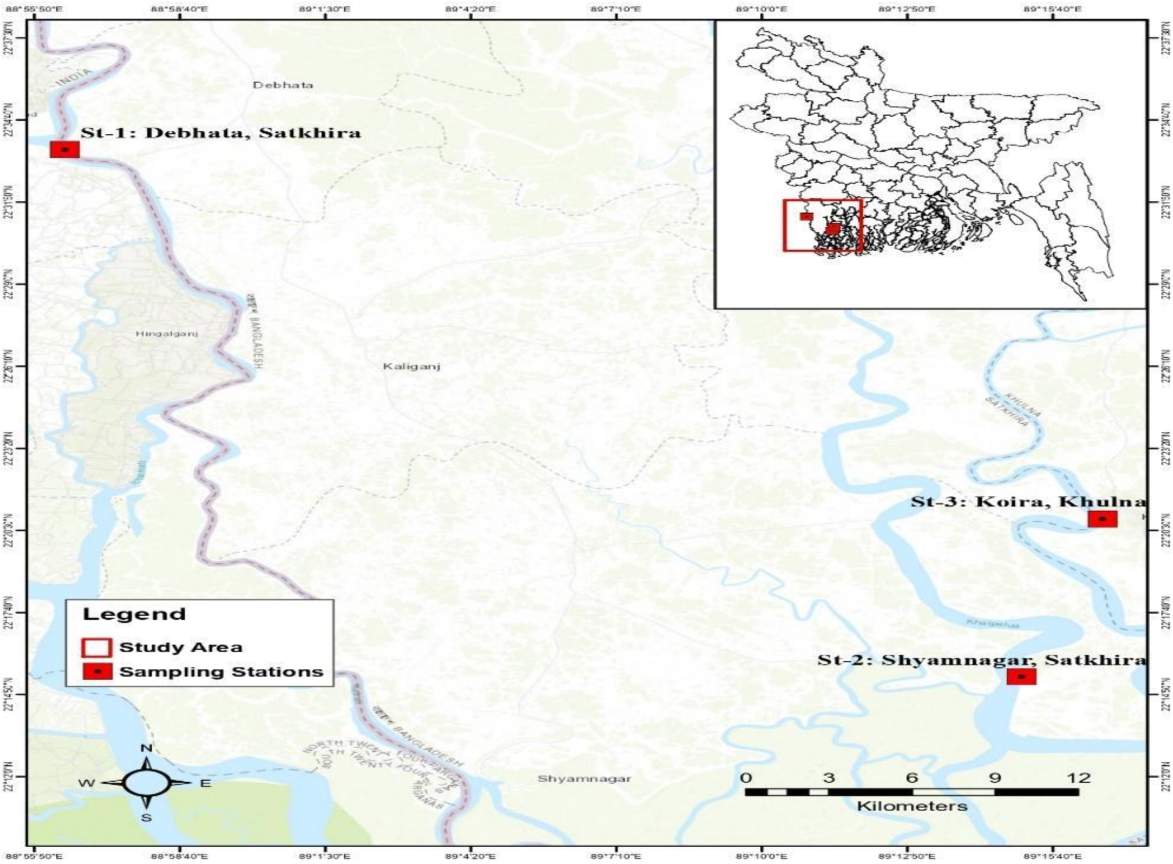

Figure 1. Study area map (using GIS tools)

3. RESULTS

The catch composition of various species and groups with Fixed Bag Net (FBN) and Push Net (PN) is shown at Debhata, Shyamnagar and Koira (Figure 2, and Table 1). The largest catch of baby shrimp (*Penaeus monodon*) was Debhata (0.83%) at the same time Shyamnagar (0.60%) and Koira (0.67%) with FBN. In the case of FBN, the percent composition of *Penaeus indicus* was high at Shyamnagar (0.39%) followed by Debhata (0.26%) and Koira (0.25%). The catch percent of *Penaeus merguiensis* was high at Debhata (0.09%) during FBN catching where Shyamnagar (0.05%) and Koira (0.08%). With FBN, the percent of *Metapenaeus monoceros* and other shrimp was high both at Koira (0.05% and 5.95%, respectively) where Debhata (0.02% and 3.24%, respectively), and Shyamnagar (0.03% and 2.47%, respectively). The most catching groups were fin-fish larvae, crab larvae and small organisms (numerous zooplankton).

Table 1. Species composition (%) with Fixed Bag Net (FBN) and PN Push Net (PN) at Debhata, Shyamnagar and Koira.

Species/Group	% of species composition					
	Debhata		**Shyamnagar**		**Koira**	
	FBN	**PN**	**FBN**	**PN**	**FBN**	**PN**
P. monodon	0.83±1.15	1.14±0.21	0.60±0.34	1.32±0.69	0.67±0.36	1.51±0.56
P. indicus	0.26±0.20	0.50±0.18	0.39±0.16	0.32±0.03	0.25±0.07	0.36±0.22
P. merguiensis	0.09±0.01	0.05±0.03	0.05±0.02	0.04±0.02	0.08±0.01	0.06±0.02
M. monoceros	0.02±0.01	0.04±0.02	0.03±0.02	0.02±0.01	0.05±0.03	0.06±0.01
Other shrimp	3.24±0.71	1.27±0.41	2.47±0.26	4.62±0.54	5.95±0.27	3.95±0.93
Fin-fish larvae	5.12±3.61	5.69±0.74	7.40±5.84	6.42±0.29	6.59±2.77	8.33±3.68
Crab larvae	5.16±2.23	3.86±0.51	7.10±1.50	6.53±1.63	5.54±1.78	7.53±2.90
Small organisms	85.29±7.88	87.47±5.25	81.96±7.88	80.73±1.93	80.86±4.57	78.19±7.52

The largest catch of fish larvae was at Shyamnagar (7.40%) followed by Debhata (5.12%) and Koira (6.59%). The catch composition of crab larvae was high at Shyamnagar (7.10%) where Debhata (5.16%) and Koira (5.54%). During the study period, amount of small organisms (numerous zooplankton) was noticeable. The catch percent of small organisms was high at Debhata (85.29%), then Shyamnagar (81.96%) and Koira (80.86%).

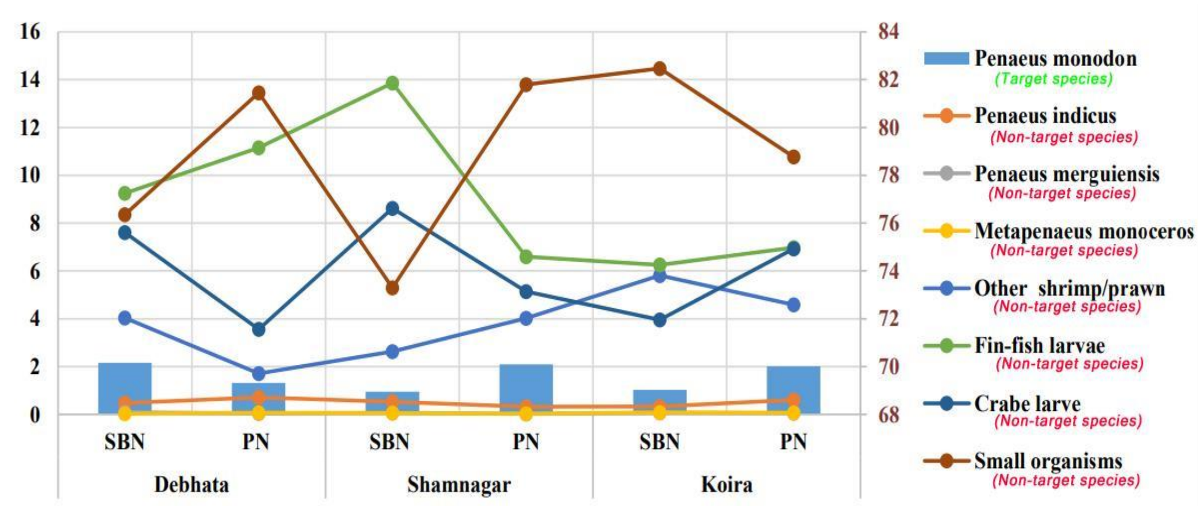

Figure 2. Species composition (%) with Fixed Bag Net (FBN) and PN Push Net (PN) at Debhata, Shyamnagar and Koira.

In the case of the second fishing gear push net (PN), the percent composition of baby shrimp (*Penaeus monodon*) was Koira (1.51%) as the same time Debhata (1.14%) and Shyamnagar (1.32%). The largest proportion of *Penaeus indicus* was high at Debhata (0.50%) followed by Shyamnagar (0.32%) and Koira (0.36%). The catch percent of *Penaeus merguiensis* was high at Koira (0.06%) where Debhata (0.05%) and Shyamnagar (0.04%). The percent of *Metapenaeus monoceros* and other shrimp was high at Koira and Shyamnagar (0.06% and 4.62%, respectively) whereas Debhata (0.04% and 1.27%, respectively), Shyamnagar and Koira (0.02% and 3.95%, respectively) (Figure 2 and Table 1). The most catching groups were also fin fish larvae, crab larvae, and small organisms (numerous zooplankton) during catch with push net (PN). The largest catch composition of fish larvae was at Koira (8.33%) where Debhata (5.69%) and Shyamnagar (6.42%). The catch composition of crab larvae was high at Koira (7.53%) followed by Debhata (3.86%) and Shyamnagar (6.53%). During the study period, amount of small organisms (numerous zooplankton) was also remarkable. The catch share of small organisms was high at Debhata (87.47%), then Shyamnagar (80.73%) and Koira (78.19%). The total catch of all organisms by a person from three study periods averagely about

2602.69 kg whereas the main target species Penae us monodon was only 25.44 kg. During the study period, due to baby shrimp collection, total amount of by-catch was 2577.25 kg per person (Table 2).

Table 2. Yearly total catch (kg) per person at the study area.

	Total catch [Kg/Year (8 months)/person]								
	Penaeus monodon	***Penaeus indicus***	***Penaeus merguiensis***	***Metapenaeus monoceros***	**Other shrimp**	**Fin-fish larvae**	**Crab larvae**	**Small organisms**	**Total**
Debhata	25.64	9.50	1.83	0.72	65.49	147.46	122.53	2198.37	2571.55
Shyamnagar	24.36	10.01	1.24	0.77	90.27	194.29	189.42	2214.96	2725.33
Koira	26.32	7.89	1.84	1.48	132.91	186.26	158.73	1995.76	2511.20
Average	25.44	9.14	1.64	0.99	96.22	176.00	156.89	2136.37	2602.69
Total	101.76	36.54	6.55	3.96	384.89	704.01	627.57	8545.46	10410.77

4. DISCUSSION

The biological, ecological, and social integrity of the aquatic socio-ecological pattern can be well-indicated by aquaculture (Pandit et al., 2019). By addressing the issues of indiscriminate exploitation and the extent of juveniles' economic harm to other fin fish during the collection of baby shrimp (*Penaeus monodon* larvae), the study aims to investigate the complexities of the socio-ecological system. The findings show that price is a significant factor in determining a fish's value.

4.1. Species composition in by-catch

This study clearly shows that 98.86-99.17% of other larvae are lost to catch 0.83-1.14% of baby shrimp at Debhat. Even, in Shyamnagar 98.68-99.40% of other larvae are lost to catch 0.60-1.32% of baby shrimp, in Koira 98.49-99.33% of other larvae are lost to catch 0.67-1.51% of baby shrimp (Table 1). *Penaeus indicus*, *Penaeus merguiensis*, *Metapenaeus monoceros*, other shrimp larvae, fin-fish larvae, crab larvae, and various small organisms are notable among other larvae. Paul et al. (1993) reported that 98.84% of other larvae are wasted for an average catch of 1.16% baby shrimp. Ahamed et al. (2012) reviewed that hatcheries are available but they are unable to provide quality full larvae. Moreover in Khulna, 99.90% of other larvae are indiscriminately harvested due to only 0.1% baby shrimp. Although, a lot of hatcheries are available in Bangladesh to provide baby shrimp, currently, the land area for shrimp farming in Bangladesh is 263025 hectares (DoF, 2021) where the number of hatcheries is 995 (BER, 2012).

Table 3. Fin fish, shellfish, and macro-zooplankton (small organisms) losses (%) during baby shrimp collection in Bangladesh's coastal waters

Study year	Other Shrimp & prawn larvae	Fin fish larvae	Macro-zooplankton (small organisms)	References
1989-90	12.75	12.64	62.12	Paul *et al.*, 1993
1990	21.5	30.8	46.5	Deb, 1998
1992	16.0	10.0	73.4	Rahman *et al.*, 1985
1995	13.2	3.2	83.2	Ahmed *et al.*, 1998
1996	7.6	2.1	90.1	Islam *et al.*, 1999
1999	17.2	7.2	75.4	Hoq *et al.*, 2001

4.2 Biomass and economic loss of fish species

The figure shows the annual loss of different larvae as a result of *Penaeus monodon* by-catch during the study period. The loss of other non-target species due to baby shrimp collection from the natural environment is a matter of concern for biologists, ecologists, and policymakers as well as environmentalists. Fisheries could be reduced in the future if this activity keeps up. In general, this activity of collecting larvae is related to people's livelihood. Coastal aquaculture undoubtedly supports rural employment and livelihood to a large extent, but ecological costs and unfavorable social consequences are currently impeding this.

Table 4. By-catch and estimated biomass after reaching maturity are compared (present study).

Non-target species	Yearly by-catch Weight (kg)	Yearly Estimated biomass (kg)	by-catch-adult biomass ratio (kg)
Penaeus indicus	9.13	271.33	0.034
Penaeus merguiensis	1.64	49.20	0.033
Metapenaeus monoceros	0.99	32.67	0.030
Other shrimp	96.22	2598.52	0.037
Fin-fish larvae	176.00	9750.29	0.018
Crab larvae	156.89	600.76	0.261
Small organisms	2136.36	9000.78	0.237
Total	2577.23	22303.55	

Ahamed et al. (2012) also discussed the indiscriminate exploitation of wild prawn post-larvae poses a threat to biodiversity, community livelihoods, and fisheries resources in Bangladesh's coastal regions. The author also summarized that the large amounts of bycatch, caused by baby shrimp (PL) fishing, is known to have a negative effect on biodiversity in coastal ecosystems. This led to the implementation of a ban on PL collection to protect fisheries resources by the government of Bangladesh. During the present study, the year-round catch for *Penaeus monodon* larvae was 101.76 kg at the south-western region (3 study locations) of Bangladesh where the by-catch was 2577.23 kg. Ultimately, the total loss due to illegal shrimp larvae collection is 22303 kg. There are thousands of baby shrimp harvesting points in this southwestern area of the country. According to Banks (2003), yearly about 2,000 million shrimp fries are harvested from wild sources in Bangladesh. More than 90% of the total protein in freshwater shrimp (*Macrobrachium rosenbergii*) and more than 50% of black tiger shrimp (*Penaeus monodon*) comes from natural sources. In the collection of a single *Penaeus monodon* post larva, Hoq et al. (2001) calculated that roughly 12–55 post-larvae of other shrimp species, 5–152 larvae of finfish, and 26–1636 other macro-zooplankton organisms were discarded. Shrimp hatchery operations rely on wild-caught brood stock instead of farmed ones in many countries. In shrimp farming, bycatch during the capture of wild broodstock is crucial.4.3 Impact on biodiversity

According to FAO (2007), while some of the coastal poor fishermen rely on the harvesting of wild prawn PL as their only source of income, this practice has significant negative effects on estuarine and marine fisheries as well as prawn stocks. This is a result of numerous non-target fin and shellfish species' larvae and juveniles being caught and discarded during the PL collection process in order to select the target species. Brackish water prawn culture, on the other hand, uses high-value species that are frequently exported along with a large portion of their production cycle.

5. CONCLUSION

Shrimp farming provides a profit but at the expense of livelihood loss, environmental harm, and related risks. Thus, more research is required on a few topics in order to achieve social justice and effective conservation. If we don't offer the locals an alternate means of subsistence, the conflict between livelihood and conservation will not be resolved. The government should provide funds to investigate different livelihood options that, by adhering to sustainable development principles, would not only offer financial security but also reinforce the community's social structure as a whole. The primary source of seed for the black tiger prawn (*Penaeus monodon*) in Bangladesh continues to be the wild baby shrimp (PL). Additionally, the harvesting of wild palm leaves provides a significant source of income for thousands of coastal landless people as well as vulnerable populations, particularly women and children. However, the very fisheries resources that the larger community depends on are destroyed as a result of the indiscriminate harvesting of wild baby shrimp. It is also impossible to overestimate the wider effects of these endeavors on the entire coastal population, the consequent loss of aquatic biodiversity, and the devastation of coastal ecosystems. These are just a few of the steps that could help preserve the marine, coastal, and estuarine fisheries by reducing the strain of overexploitation on aquatic and fisheries resources.

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STATEMENTS AND DECLARATIONS

- **Competing Interests:** I declare that the authors have no competing interests as defined by Springer, or other interests that might be perceived to influence the results and/or discussion reported in this paper**.**
- **Dual publication:** The results/data/figures in this manuscript have not been published elsewhere, nor are they under consideration by another publisher.

ETHICAL APPROVAL

Not applicable

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Review **Derleme**

The Risk of Antibiotic Resistance in Aquaculture: The Future Outlook

Su Ürünleri Yetiştiriciliğinde Antibiyotik Direnci Riski: Geleceğe Bakış

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Abstract: The production of aquatic products is a critical global industry that provides employment and livelihoods to millions of people, aiming to compensate for the increasing population and insufficient terrestrial resources. To bridge the demand–supply gap in seafood production, the use of production technologies in the industry has intensified, but has raised concerns about potential public health threats. For instance, increased stocking densities in aquaculture settings have increased fish stress, creating an environment conducive to pathogen proliferation. Antibiotics are widely used to treat and prevent infections in fish and other animals. The emergence of antibiotic-resistant bacteria in fish and other aquatic animals, as well as in the aquatic environment, has created reservoirs of resistant bacteria and resistance genes. To some extent, antibiotic resistance in aquaculture has contributed to resistance to antimicrobial agents in human pathogens thereby severely limiting therapeutic options during human infections. Therefore, responsible and monitored use of antibiotics in aquaculture is paramount. This review consolidates the knowledge on commonly used antibiotic types in aquaculture, antibiotic administration, antibiotic susceptibility test techniques, and antibiotic resistance in water, fish, and sediments. The challenges, strategies, and constraints in counteracting antibiotic resistance and prospects for antibiotic use in aquaculture are discussed.

Keywords
- Fish
- Water
- Bacteria
- Environment
- Seafood

Özet: Su ürünleri üretimi, artan nüfus, karasal kaynakların yeterli olmamasına bağlı olarak açığı karşılamak adına milyonlarca insana istihdam ve geçim sağlayan kritik bir küresel endüstridir. Sektördeki üretim teknolojilerinin yoğunlaşması, deniz ürünleri üretimindeki arz-talep açığını kapatmak için ortaya çıkmıştır, ancak potansiyel halk sağlığı tehditlerine ilişkin endişeler gündeme gelmiştir. Örneğin, su ürünleri yetiştiriciliği ortamlarında artan stok yoğunlukları balıklarda stresin artmasına yol açarak patojen çoğalmasına elverişli bir ortam yaratmıştır. Antibiyotikler balıklarda ve diğer hayvanlarda bakteriyel enfeksiyonların tedavisinde ve önlenmesinde yaygın olarak kullanılmaktadır. Balıklarda ve diğer su canlılarında, ayrıca sucul ekosistemlerde antibiyotiklere dirençli bakterilerin ortaya çıkması, dirençli bakterilerin ve direnç genlerinin rezervuarlarını oluşturmuştur. İnsan patojenlerindeki antimikrobiyal maddelere karşı direnç, insan enfeksiyonları sırasında tedavi seçeneklerini ciddi şekilde sınırlamaktadır. Bu derleme, su ürünleri yetiştiriciliğinde yaygın olarak kullanılan antibiyotik türleri, antibiyotik uygulaması, antibiyotik duyarlılık test teknikleri ve su, balık ve sedimentteki antibiyotik direnci hakkındaki bilgileri bir araya getirmektedir. Antibiyotik direnciyle mücadelede karşılaşılan zorluklar, stratejiler ve kısıtlamaların yanı sıra su ürünleri

Anahtar kelimeler
- Balık
- Su
- Bakteri
- Çevre
- Deniz ürünleri

yetiştiriciliğinde antibiyotik kullanımına yönelik beklentiler de tartışılmaktadır.

1. INTRODUCTION

Seafood farming has long been a vital source of nutrition and income for people worldwide (Charlton et al., 2016; Nyboer et al., 2022; Popoola, 2022). Aquaculture has intensified to meet the growing global demand for seafood. Intensification increases production efficiency, yields, and enables more sustainable use of aquatic resources. It addresses the challenges of overfishing and provides a controlled environment for optimizing fish growth. Additionally, intensified aquaculture contributes to economic development by creating employment opportunities and supporting the livelihoods of millions of people worldwide (Kumar et al., 2020; Morshdy et al., 2022; Opiyo et al., 2018). That notwithstanding, intensive aquaculture has consequently increased the frequency of fish stressors, including the proliferation of diverse disease-causing microorganisms, particularly pathogenic bacteria (Chang et al., 2020; Lulijwa et al., 2020; Oviedo-Bolaños et al., 2021; Romero et al., 2012; Zhang et al., 2023). Largely antibiotics have being widely used to prevent and treat bacterial diseases in fish culturevia fish feed, baths or immersion, and injections, amongst others (Gupta et al., 2019; Hurdle et al., 2011; Imran et al., 2022; Shan et al., 2018; Terzi et al., 2020). There have been widespread reports of indiscriminate use of antibiotics in fish farming, leading to antibiotic resistance in the pathogen population (Capkin et al., 2015). Upon exposure to antibiotics, vulnerable bacteria perish allowing surviving ones to transmit resistance traits to future generations through biological mutations, DNA exchange, and rapid replication. (Begum et al., 2018; Frieri et al., 2017; MacGowan and Macnaughton, 2017; Ray et al., 2017). Antibiotic resistance in fish poses a global threat to public health. Resistant bacteria in fish can be transmitted to humans through the consumption of contaminated fish or environmental pathways (Fletcher, 2015; Skandalis et al., 2021). If not curtailed, the continued development of antibiotic resistance in fish may impede Sustainable Development Goal 3, which aims to promote good health and well-being (MacGowan & Macnaughton, 2017).

In this review, we discuss commonly used chemicals in fish health, routes of antibiotic administration, commonly used antimicrobial susceptibility testing techniques, and antibiotic resistance in water, fish, and sediment. The challenges, strategies, and constraints in counteracting antibiotic resistance, and prospects for antibiotic use in aquaculture are discussed as well. We hope that the knowledge shared in this review will enhance our understanding of antibiotic usage and pragmatic ways to help curb the growing menace associated with its use in aquaculture.

1.1. Antibiotic Groups Used in Aquaculture

Commonly used antibiotics in aquaculture include various substances. According to Schar et al. (2020), antibiotics such as quinolones, tetracyclines, amphenicols, and sulfonamides, which are classified as critically important for human medicine by the World Health Organization (WHO), account for 27%, 20%, 18%, and 14% use in aquaculture operations respectively. Other classes of antibiotics such as cephalosporins, lincosamides, and macrolides are less used in aquaculture. Enrofloxacin (Dawoodet al., 2018), chloramphenicol and amoxicillin (Apenteng et al., 2022; Abarike et al., 2023) are emerging antibiotics currently used in aquaculture settings (Corum et al., 2022; Uney et al., 2021). The choice of antibiotics in aquaculture is influenced by susceptibility of the fish species to various bacterial diseases, availability and accessibility of different antibiotics, ability to accurately diagnose diseases, presence of antibiotic-resistant bacteria, and regulations in the target markets for fish products, especially those related to food safety and certifications.

1.2. Antibiotic Administration in Aquaculture

In aquaculture, various fish species are commonly treated with antibiotics to manage bacterial infections and ensure their health. In Table 1, fish species, commonly used and routes/mode of antibiotic administration methods in aquaculture are shown.

Table 1. Examples of culture fish, antibiotic types, and route of administration**.**

Fish Species	Antibiotic (s) Used	Mode of Administering	References
Catfish (*Clarias gariepinus*)	Oxytetracycline and furasol	Oral	(Lawal, et al., 2012)
European sea bass larvae (*Dicentrarchus labrax L.,*)	Oxolinic acid	Bath	(Touraki et al., 2012)
Nile tilapia (*Oreochromis niloticus*)	Florfenicol	Oral	(Gaikowski, et al., 2013)
Fairy shrimp (*Branchinella thailandensis*)	Sodium hypochlorite, oxytetracycline dehydrate and chloramphenicol	Bath	(Saejung et al., 2014)
Pangasius catfish	Enrofloxacin and ciprofloxacin	Oral	(Andrieu et al., 2015)
Nile tilapia (*O. niloticus*)	Chlortetracycline, doxycycline, florfenicol flumequine, nalidixic acid sulfadiazine sulfathiazole	Oral and injection	(Mostafa et al., 2017)
Nile tilapia (*Oreochromis niloticus)*	Oxytetracycline (OTC)	Oral and bath	(Julinta et al., 2017)
Crucian carp (*Carassius auratus gibelio*)	Enrofloxacin	Oral, intramuscular and bath	(Shan et al., 2018)
Nile tilapia (*Oreochromis niloticus*)	Oxytetracycline	Oral	(Limbu, et al., 2019)
Nile tilapia (*Oreochromis niloticus)*	Emamectin benzoate	Oral	(Julinta et al., 2020)
Rainbow trout (*Oncorhynchus mykiss*)	Danofloxacin	Oral and injection (intravenous, intramuscular)	(Terzi et al., 2020)
Rainbow trout (*Oncorhynchus mykiss*)	Enrofloxacin	Implantation	(Hjelmstedt et al., 2020)
Yellow catfish (*Pelteobagrus fulvidraco*)	Doxycycline	Oral	(Xu, et al., 2021)
Olive flounders (*Paralichthys olivaceus*)	Lincomycin	Injection	(Lee et al., 2022)
Rainbow trout (*Oncorhynchus mykiss)*	Doxycycline	Injection (IV), (IM) and oral gavage	Altan et al., 2024
Rainbow trout (*Oncorhynchus mykiss)*	Doxycycline	Injection (oral gavage)	Corum et al., 2023
Rainbow trout (*Oncorhynchus mykiss)*	Oxytetracycline	Injection (oral gavage)	Corum et al., 2023
Nile tilapia (*Oreochromis niloticus*)	Enrofloxacin	Injection (IV), (IP) and oral gavage	Corum et al., 2022
Rainbow trout (*Oncorhynchus mykiss)*	Cefquinome	Injection (IV), (IP) and oral gavage	Durna Corum et al., 2022

1.3. Oral Route

Oral administration is done by adding antibiotics to the water in which fish live or by mixing it with the feed administered (Shan et al., 2018; Terzi et al., 2020). The majority of practitioners use this method though there are concerns. For instance, oral administration of antibiotics leaves large amounts of antibiotic residues in the environment. In addition, fish do not effectively metabolize antibiotics and will pass approximately 75% of unused antibiotics back into the environment through feces (Okocha et al., 2018). Thus, this method has several disadvantages. Oral methods invariably contribute to the development of drug-resistant bacteria. Resistant bacteria can survive and multiply in the presence of those antibiotics, whereas susceptible bacteria can be eliminated. This can lead to the proliferation of resistant strains, thereby increasing the overall level of antibiotic resistance in aquaculture environments (Watts et al., 2017). The oral administration of antibiotics in aquaculture can facilitate the transfer of resistance genes from antibiotic-exposed bacteria to others present in aquatic environments, thus increasing bacterial resistance (Sáenz et al., 2019). Other theoretical perspectives indicate that orally administered antibiotics could remain in the water and can contribute to the contamination of aquatic ecosystems when discharged through effluents from aquaculture facilities, promoting the development and persistence of antibiotic resistance in environmental bacteria (Okon et al., 2022). Oral antibiotics used in aquaculture can also affect non-target organisms, including bacteria that are beneficial or part of the natural microbial community. Disruption of the normal microbiota in aquatic environments can create ecological imbalances, allowing opportunistic or resistant bacteria to thrive.

1.4. Injection

Antibiotics could be injected intramuscularly, intraperitoneally, or intravenously into individual fish in response to a diseases situation. This enables precise dosage delivery and quicker action than other administration methods (Lee et al., 2022; Mostafa et al., 2017). Similarly, injecting antibiotics into fish can also contribute to the development of increased antibiotic resistance in aquaculture through various means, as described previously for oral administration. Moreso the injection method may not reach all infected fish in the population. This is because infections in aquaculture settings can spread rapidly, and treating individual fish can be logistically challenging. Thus, pathogenic bacteria may still persist and can potentially develop resistance to the antibiotics used. Unsuccessful eradication creates opportunities for bacterial transmission to other fish, further spreading antibiotic-resistant strains (Skandalis et al., 2021). In addition, administering an appropriate dosage of antibiotics through injection can be challenging. Sometimes, underdosing occurs when the antibiotic concentration is insufficient to eliminate bacteria, which can again lead to the development of resistant strains (Pereira et al., 2022; Rossiter et al., 2017). Conversely, overdosing a times occurs leading to the selection and survival of more resistant bacteria that can withstand higher antibiotic concentrations (Manyi-Loh et al., 2018; Raju et al., 2022).

1.5. Bath Administration

This method of administration works well for skin and gill infections but may contaminate the environment and lead to the growth of antibiotic-resistant bacteria (Saejung et al., 2014; Touraki et al., 2012). Also, bath treatments may result in variable doses and exposure levels in individual fish within a population (Jansen et al., 2016; Limbu et al., 2018). Factors such as fish size, behavior, and water flow can affect the amount of antibiotics absorbed by fish (Yukgehnaish et al., 2020). This can lead to inconsistent treatment outcomes and inconsistent effectiveness in controlling infections. Bath treatments expose the target pathogens and the normal microbiota and non-target organisms of fish in the aquatic environment to antibiotics. This exposure can disrupt the natural microbial balance, potentially leading to the development of antibiotic resistance in non-target bacteria and impacting the overall ecological health of the system. The exposure of bacteria to sub-lethal concentrations of antibiotics during bath treatments can promote the selection and survival of antibiotic-resistant strains. Resistant bacteria can emerge and spread within a treated population or be released into the environment, thereby contributing to the overall problem of antibiotic resistance (Bengtsson-Palme et al., 2018; Serwecińska, 2020; Ye et al., 2021).

Aquaculture operators and researchers need to carefully consider the specific requirements of the aquaculture system and adhere to the regulations and best practices for responsible antibiotic use to address the challenges associated with the oral, injection, and bath methods of administering antibiotics to cultured fish. In addition, antibiotic resistance can be minimized by using antibiotics only when necessary, adhering to proper dosage guidelines, following withdrawal periods, and considering alternative disease management strategies, such as using probiotics and prebiotics, which minimize the use of antibiotics.

Implementing good aquaculture management practices, such as improving water quality, optimizing nutrition, and enhancing biosecurity measures, can also help reduce the reliance on antibiotics and promote a healthier and more sustainable aquaculture industry (Treves-Brown, 2013).

1.6. Common Antibiotic Susceptibility Tests used in Aquaculture

Antibiotic susceptibility testing is essential for controlling bacterial infections in fish (Syal et al., 2017; Terzi et al., 2020). This test helps to monitor the emergence of antibiotic-resistant bacteria and determine which antibiotics should be used to treat bacterial infections (Baltekin et al., 2017; Syal et al., 2017). This examination has shown promise in aquaculture environments and is crucial for controlling bacterial infections in fish populations. Finding the best antibiotics to treat bacterial infections in fish is paramount for breeding healthy fish for consumption. To date, disk diffusion and microdilution are the two predominant techniques used to analyze antibiotic susceptibility tests (Goel et al., 2009; Jayachandran et al., 2018). Generally, antibiotic susceptibility test (AST) methods have major limitations. This includes the constantly evolving bacteria antibiotic resistance mechanisms of bacteria that enable them to adapt and develop new mechanisms to evade antibiotics. As traditional AST methods rely on established resistance patterns, continually evolving can evade these methods as they become outdated and fail to detect emerging resistance. Therefore, traditional susceptibility test methods may not accurately detect certain types of resistance, such as low-level resistance, inducible resistance, or specific mechanisms, such as efflux pumps or enzymatic inactivation of antibiotics. This can lead to the misinterpretation of susceptibility results and inappropriate antibiotic selection. Testing the susceptibility of certain bacteria is inherently challenging because of their slow growth and fastidious nature. Examples include certain species of Mycobacterium and anaerobic bacteria (Van Belkum et al., 2020). These organisms may require specialized test methods or prolonged incubation periods, further adding to the time and complexity of susceptibility testing. Bacteria with biofilm features can exhibit increased antibiotic resistance compared with their planktonic counterparts. Therefore, standard susceptibility test methods may not adequately capture the antibiotic resistance displayed by biofilm-associated bacteria. Antibiotic susceptibility testing is typically performed under laboratory conditions, which may not completely represent the complex environment encountered in fish bodies during infection. Factors such as the host immune response, bacterial interactions, and tissue penetration of antibiotics cannot be fully simulated in vitro. As a result, susceptibility test results may not always accurately predict the clinical response to antibiotics (Ahmed et al., 2018; Berlanga et al., 2017; Sønderholm et al., 2017).

1.7. Disc Diffusion Method

The disk diffusion method, a longstanding approach in AST, remains widely used due to its versatility and applicability for testing most bacterial pathogens (Matuschek et al., 2014). To interpret AST results, critical values called breakpoints are employed. These breakpoints define the boundary between susceptibility and resistance for each antimicrobial agent International organizations, such as the Clinical and Laboratory Standards Institute (CLSI) and the European Committee on Antimicrobial Susceptibility Testing (EUCAST), establish these breakpoints (Satlin et al., 2020). While various European national antimicrobial breakpoint committees (e.g., BSAC, CA-SFM, DIN, and SRGA) have developed their own disk diffusion methods, there was no standardized method calibrated to European breakpoints. Consequently, EUCAST initiated the development of a harmonized disk diffusion method calibrated to the minimum inhibitory concentration (MIC) for accurate interpretation of results (Matuschek et al., 2014).

In the disc diffusion method, a petri dish containing isolated fish-derived bacterial colonies is positioned on sterile paper discs with a specific antibiotic concentration (Jonasson et al., 2020). As the antibiotics diffused out of the disc and into the agar medium, the zone of inhibition surrounding the disc is measured. The susceptibility of bacteria to antibiotics can be determined by the size of the zone of inhibition (Bakht et al., 2011; Jonasson et al., 2020). Several aquaculture studies have used the disk diffusion assay as a model to study antibiotic susceptibility potency against isolates from fish species. Recently, Wanja et al. (2020) used the disk diffusion assay to study the susceptibility rate of some selected antibiotics (including ampicillin, tetracycline, co-trimoxazole, streptomycin, kanamycin, gentamicin, and chloramphenicol) on some 48 isolates belonging to *Aeromonas, Proteus, Klebsiella, Citrobacter, Salmonella, Streptococcus, Pseudomonas, Escherichia, Serratia*, and *Micrococcus*. They reported that the overall susceptibility rates for each antibiotic for all the bacterial isolates were the highest for gentamicin (100%, n = 48) and kanamycin (92%, n = 44). In addition, Wamala et al. (2018) used a disk diffusion assay to evaluate the susceptibility of 14 antibiotics against isolates (*Aeromonas hydrophila, Aeromonas sobria, Edwardsiella tarda, Flavobacterium* spp, and *Streptococcu*s spp.) from *Oreochromis niloticus* (Nile tilapia) and *Clarias gariepinus* (African catfish). This study revealed that all isolates tested were susceptible to at least ten of the 14 antibiotics evaluated. Through a disc diffusion assay, they further revealed that all isolates expressed high levels of resistance to penicillin, oxacillin, and ampicillin. Moreover, using a disc diffusion assay, Pauzi et al. (2020) reported the antibiotic resistance of *A. hydrophila* to amikacin, ampicillin, cefotaxime, amoxicillin, trimethoprim-sulfamethoxazole, erythromycin, and streptomycin, with a multiple antibiotic resistance index of 0.5. This indicates that these drugs are not sufficiently potent to kill the aforementioned isolates, making it imperative to look for alternative antibiotics when the disease persists. We are optimistic that studies of this nature will provide baseline information for future reference and fish disease management.

1.8. Broth Microdilution Method

The broth microdilution method involves evaluating the resistance of bacteria to various antibiotic concentrations in a liquid medium. Following incubation, the bacteria are cultured in wells containing antibiotics at different concentrations and bacterial growth evaluated. The concentration at which bacterial growth is inhibited is known as the minimum inhibitory concentration (MIC) of that antibiotic (Indira, 2014; Pfaller & Diekema, 2012). It is important to note that the appropriate antibiotic susceptibility test depends on the type of bacteria being examined. Microdilution assays provide valuable information regarding the sensitivity of pathogens to antimicrobial substances and aid in determining appropriate treatment regimens in aquaculture. For example, Assane et al. (2021) used a broth microdilution method to evaluate the susceptibility of *A. jandaei* isolates from tilapia to enrofloxacin, florfenicol, oxytetracycline and thiamphenicol. They reported that strains isolated from tilapia in an earthen pond were resistant to oxytetracycline, whereas strains isolated from fiberglass tanks were sensitive to all antimicrobials. Monitoring changes in inhibition concentration values over time can help detect emerging resistance trends, allowing for the early implementation of appropriate management strategies and the development of alternative treatment options.

1.9. Multidrug Resistance Bacteria in Aquaculture

The rise of multidrug-resistant (MDR) strains poses a significant global challenge in both veterinary medicine and human health. An isolate is classified as MDR if it exhibits resistance to three or more classes of antimicrobials (Leal et al 2023). Bacteria exposed to antibiotics or other antimicrobials may develop resistance through a variety of mechanisms, such as mutations and bacterial acquisition of resistance genes (Algammal et al., 2022; Sivaraman et al., 2020). Antibiotics are commonly detected in aquaculture water with geographical variations due to different farming practices and species composition (Yuan et al 2023). The prevalence and distribution of MDRisolates in water sources represent a critical global issue with significant implications for public health. Numerous surveillance studies have highlighted the alarming presence of MDR bacteria in various water bodies, including rivers, lakes, and municipal water supplies. For example, bacterial strains including *Salmonella, Escherichia coli, Pseudomonas* spp., *Aeromonas* spp., and *Vibrio* spp. have been identified as the most prevalent MDR found in water (Legario et al., 2020; Patil et al., 2016; Yang et al., 2017). Antibiotic presence in water could be affected by solubility, frequency of use, and growth stages of cultured organisms. Environmental conditions such as dry seasons and extreme temperatures, also influence antibiotic concentrations (Yuan et al 2023). Factors such as antibiotic pollution, contamination from human and animal waste, and the potential for horizontal gene transfer contribute to the emergence and persistence of MDR isolates in the aquatic environment. Martínez (2015) and Chen et al. (2019) demonstrated that antibiotic residues in water can create selective pressures, driving the evolution of antibiotic resistance in aquatic environments. A report by Ikhrami et al. (2024) showed that antibiotic resistance genes have recently emerged as environmental contaminants. Water from irrigation canals, which receives contamination from river pollutants, can become a hotspot for antimicrobial resistant genes such as sulfonamide (sul1), tetracycline (tetA), beta-lactam (blaGES), and multidrug resistance.

In addition to the immediate health risks posed by MDR isolates in water, there are broader concerns regarding their impacts on ecosystems and the environment. The presence of antibiotic-resistant bacteria in aquatic ecosystems can disrupt the ecological balance and biodiversity, potentially leading to long-term environmental consequences. Studies conducted by D'Costa et al. (2011) and Wright (2016) highlighted the role of aquatic environments in facilitating the transfer of resistance genes between bacteria and accelerating the spread of antibiotic resistance. Furthermore, the spread of antibiotic resistance through water sources has implications beyond human health and affects agriculture and animal husbandry. Aquaculture serves as a hotspot for the transfer of resistance genes. In a review by Hossain et al (2022), MDR strains are increasingly detected in fish and the aquaculture environment, posing a significant threat to medical treatment options and contributing to unwanted deaths. Also, effluents from wastewater treatment plants on farm ways can increase the prevalence of antibiotic resistance bacteria in waterbodies. It has been found that MDR bacteria isolates persist in aquatic environments and these bacteria isolates possess genes associated with resistance. In some studies, for instance, *Aeromonas* spp. strains from urban wastewater treatment and *Clostridium perfringens* from water samples have been reported. Sustainable solutions should prioritize the protection of public health, the preservation of ecosystems, and the promotion of responsible antibiotic usage across various sectors, as emphasized by Larsson (2014) and Collignon et al. (2018). Considering all of the above, a conclusion can be made that the interconnectedness of aquaculture, terrestrial environments, and human populations facilitates bacterial transmission. The One Health concept, recognizing links between human, animal, and environmental health, offers a holistic approach to tackle antimicrobial resistance. By embracing this approach, we can safeguard the future of aquaculture while ensuring health, food safety, and environmental protection (Milijasevic et al., 2024). Understanding these factors and their geographical and seasonal variations is essential for devising effective mitigation strategies. Such strategies include improving water treatment processes, promoting antibiotic stewardship, and adopting a One Health approach that integrates efforts across human and veterinary medicine, agriculture, and environmental sciences. By collectively addressing this issue, as proposed by Wang et al. (2021), we can work towards safeguarding water quality and minimizing the risks associated with MDR bacteria in water sources, ensuring access to safe and clean water. Some other fish-related bacteria with antibiotic resistance genes have also been isolated from fish. For example, *Listeria innocua* isolated from catfish fillets and *Enterococcus faecium* strain isolated from ready-to-eat raw fish have been reported in rainbow trout. The dissemination of antibiotic resistance genes in the environment poses a significant concern (Chen et al., 2010). Table 2 shows bacteria isolates with antimicrobial resistance from commonly cultured fish.

Table 2. Bacterial isolates with antimicrobial resistance from commonly cultured fish.

Fish Species	Isolates	Aquaculture Facility	Resistance to Antibiotic (s)	References
Catfish	*Aeromonas hydrophila*	Pond	Tetracycline	(Nawaz et al., 2006)
Nile tilapia	*Aeromonas caviae*	Wet market	Tetracycline, nitrofurantoin and augmentin	(Ashiru, et al., 2011)
Catfish (*Clarias gariepinus*) and Tilapia (*Tilapia mossambica*)	*Salmonella spp.*	Wet market and ponds	Chloramphenicol, clindamycin, rifampicin, spectinomycin, and tetracycline	(Budiati et al., 2013)
Diseased catfish (*Clarias gariepinus*)	*Aeromonas hydrophila*	River	Ampicillin	(Laith & Najiah, 2014)
African catfish *(Clarias gariepinus)*	*Salmonella Spp.*	Fish farm and wet market	Penicillin, clindamycin, tetracycline, and rifampicin	(Sing et al., 2016)
Common carp (*Cyprinus carpio carpio*) fingerlings	*Aeromonas Spp.*	Pond	Sulfadiazine-trimethoprim, oxytetracycline, florfenicol	(Patil et al., 2016)
Channel catfish	*Aeromonas veronii*	River	Ciprofloxacin, levofloxacin, and norfloxacin	(Yang et al., 2017)
Red hybrid tilapia (*Oreochromis* spp.)	*Aeromonas hydrophila* and *Edwardsiella tarda*	River	Novobiocin, ampicillin, spiramycin, and chloramphenicol	(Lee & Wendy, 2017)
Nile tilapia (*Oreochromis niloticus*)	*Streptococcus iniae* and *Streptococcus agalactiae*	Grow-out cages, ponds and hatcheries	Oxolinic acid, sulphamethoxazole-trimethoprim	(Legario et al., 2020)
Pangasius catfish (*Pangasius hypophthalmus*)	*Escherichia coli*	Freezing factories	Colistin, ampicillin, cefotaxime, streptomycin, meropenem, tetracycline, sulfamethoxazole/trimethopr im and nalidixic acid	(Salako et al., 2020)
Nile tilapia	*Aeromonas hydrophila, A. veronii, Pseudomonas fluorescens* and *P. aeruginosa*	Fish farm	Sulphonamide and tetracycline	(Sherif et al., 2021)
Nile tilapia	*Streptococcus Spp.*	Fish farm	Florfenicol and tetracycline	(Oviedo-Bolaños et al., 2021)
Yellow catfish	*Aeromonas vero nii*	Pond	Ampicillin, tetracycline, trimethoprim-sulfamethoxazole	(Li, et al., 2022)

Verner-Jeffreys et al. (2009) observed a high prevalence of MDR bacteria and associated antimicrobial resistance genes in ornamental fish. For example, 47 of 94 *Aeromonas* spp. isolates recovered from tropical ornamental fish were tolerant to 15 or more antibiotics, representing seven or more classes of antimicrobials. The quinolone and fluoroquinolone resistance gene, qnrS2, was detected at a high frequency (37% of tested recent isolates were positive using PCR). In addition, the study found that (17.7%) of the isolates were identified as target microorganisms (high and critical priority pathogens on the WHO list). The same study reported that 80% of 628 strains of tetracycline-resistant (Tetr) and sulphamethoxazole-resistant (Sulr) bacteria associated with fish and shrimp samples were found resistant to more than one antibiotic. These findings suggest that ornamental fish act as reservoirs for both MDR bacteria and their resistance genes. Aeromonas pathogens were found in the gut and skin of treated fish, and biofilms became MDR to streptomycin, sulfamethoxazole, quinolones, fluoroquinolones, oxytetracycline, florfenicol, chloramphenicol, and trimethoprim. This increases the transfer of relevant genes to wider aquatic environments during harvesting (Naviner et al., 2011). These findings suggest that aquaculture fish also act as a reservoir for both MDR bacteria and resistance genes (Arias-Andres et al., 2018). The prevalence and distribution of MDR isolates in fish can be attributed to various factors, including the use of antibiotics in aquaculture. Miranda et al. (2018) highlighted the role of antibiotic use in fish farming as a major driver of antibiotic resistance in aquatic systems. Additionally, the interconnectedness of aquatic ecosystems enables the exchange of resistance genes between bacteria, facilitating the spread of resistance, as demonstrated in a study on fish by Bhullar et al. (2012). There is a correlation between the prevalence and distribution of MDR isolates in fish and their habitats. We hypothesized that lay aquaculture practitioners may have difficulty understanding the aetiology of these isolates and may misapply antibiotics to which the isolates have developed drug resistance. It is clear that efforts to reduce the prevalence of MDR bacteria in fish must take into account both environmental and human health impacts. Generally, antibiotic concentrations and ARG abundance in sediment are much higher than those in water (Yuan et al 2023). Antibiotics present in the water column can adhere to suspended particulate matter and eventually settle into sediment. Sediments tend to accumulate antibiotics due to their gradual hydrolysis in water. Numerous studies have demonstrated that antibiotic concentrations in sediments are higher than in water, primarily because of greater stability. In aquaculture settings, antibiotic residues may progressively accumulate in sediment, potentially contributing to the evolution of antibiotic-resistant pathogens (Yuan et al., 2023).

The presence and distribution of MDR bacteria in aquatic sediments represent a critical environmental concern with potential implications for both ecosystems and human health. Factors contributing to the emergence and persistence of MDR bacteria in sediment environments are multifaceted. Sediments can act as sinks for antibiotic residues and resistance genes, providing favorable conditions for the selection and maintenance of antibiotic-resistant bacteria. Munir et al. (2011) demonstrated the accumulation of resistance genes in the sediments of a river receiving effluents from wastewater treatment plants. Additionally, sediment bacteria can exchange resistance genes through horizontal gene transfer, as shown in the research by Ma et al. (2019). Several studies have examined the prevalence of MDR bacteria in sediment samples collected from aquatic environments. For example, Amos et al. (2015) reported a high prevalence of antibiotic-resistant bacteria in sediment samples from rivers, lakes, and coastal areas, highlighting the extensive distribution of MDR bacteria in sediment matrices (Amos et al., 2015). Furthermore, a study conducted by Czekalski et al. (2016) investigated sediment samples from wastewater treatment plants and identified MDR bacteria, suggesting that these treatment systems may serve as reservoirs for antibiotic-resistance genes in sediment environments (Czekalski et al., 2016). Mitigating the prevalence of MDR bacteria in sediments is crucial for protecting aquatic ecosystems and minimizing potential human health risks.

1.10. Challenges Associated with Antibiotic Resistance in Aquaculture

The effects of antibiotic resistance in cultured fish are diverse. This poses a challenge for fish farmers, as it becomes increasingly difficult to treat infections effectively and maintain fish health (Algammal et al., 2022; Lafferty et al., 2015; Minich et al., 2018; Wamala et al., 2018). This can lead to higher mortality rates, slower growth rates, and financial losses for the fish farmers. Antibiotic-resistant bacteria present in aquaculture systems have the potential to spread to surrounding water bodies, potentially affecting other aquatic organisms, such as wild fish, and disrupting the ecological balance, aggravating the issue on a broader scale (Okeke et al., 2022; Preena et al., 2020).

Antibiotic-resistant bacteria in aquaculture pose a risk to human health. If fish-carrying resistant bacteria are not properly processed before consumption, transfer of antibiotic-resistance genes to humans is possible. This can compromise the effectiveness of antibiotics in treating human infections and contribute to the overall burden of antibiotic resistance in humans. The transmission of antibiotic-resistant bacteria from aquaculture to humans raises concerns regarding the risk of treatment failure and the limited availability of effective antibiotics to combat bacterial infections in both medical and agricultural contexts (Bengtsson-Palme et al., 2014; Collignon et al., 2018).

Addressing antibiotic resistance in aquaculture requires a holistic approach emphasizing antibiotic use, disease prevention strategies, and robust surveillance systems. It is important to address the problem of antibiotic resistance in fish culture through open discussions among aquaculture farmers, governments, and researchers. These discussions should aim to develop and promote sustainable aquaculture practices that prioritize fish health and environmental and human well-being. Implementing responsible and careful use of antibiotics, strengthening biosecurity measures, promoting disease prevention through effective management practices, exploring alternative strategies for disease control, such as vaccines and probiotics, and improving the management of water quality in aquaculture systems should be priorities (Barnes et al., 2022; Desbois et al., 2021; Garza et al., 2022). Additionally, there is a need to increase the surveillance and monitoring of antibiotic resistance in aquaculture settings to guide evidence-based interventions and policy decisions (Hoa et al., 2011).

1.11. Strategies to Deal with Antibiotic Resistance in Aquaculture

Addressing antibiotic resistance in aquaculture is a critical challenge for the industry and public health. According to WHO 2014, there is a need to encourage and promote responsible antibiotic use in human and veterinary medicine to minimize unnecessary antibiotic use. Various strategies include:

1. Reduced antibiotic use. This is considered a fundamental strategy and includes limiting the prophylactic and growth-promoting use of antibiotics. In a study by Li et al. (2018), the impact of increasing antibiotic resistance in water was reduced by regularly monitoring water sources for the presence of antibiotics and resistant bacteria to identify contamination and track changes in resistance patterns. This information can be useful for implementing appropriate control measures. Belkina et al. (2017) stressed the need to raise public awareness and conduct educational campaigns on antibiotic resistance and its environmental impact, as this could lead to impactful behavioral changes.

2. Alternative disease management practices. Adopting alternative disease management practices is crucial. Research suggests the potency of probiotics, immune stimulants, and herbal remedies as alternatives to antibiotics (Dangtip et al., 2019). Medicinal plants are gaining recognition as sustainable alternatives to antibiotics in aquaculture. Recent studies underscore the effectiveness of these natural compounds in boosting the immune response of aquatic species, thereby reducing dependence on synthetic antibiotics (Bondad-Reantaso et al., 2023). These plants provide eco-friendly solutions with minimal environmental impact and help address the issue of antibiotic resistance (Rahimi et al., 2022). The presence of phytogenic compounds such as phenolics, essential oils, pigments, alkaloids, terpenoids, tannins, polypeptides, polysaccharides, steroids, and flavonoids has shown promising results as immunostimulants, antibacterials, antioxidants, antiparasitics, and antivirals (Abdallah et al., 2023).

3. Enhanced monitoring and surveillance. There is a need for better data collection and reporting of antibiotic usage to track resistance patterns in aquaculture settings (Cabello,2006).

4. Improved farm management. Practices, such as improved water quality control and reduced stocking densities, can help prevent disease outbreaks, reducing the need for antibiotics (Mohanty et al., 2019).

5. Regulatory measures. Regulating the use of certain antibiotics in aquaculture is pertinent and has been proposed by several research studies. For instance, Rico et al. (2014a) discuss the potential benefits of stricter regulations on antibiotic use in fish farming.

6. Design of novel antibiotics to mitigate antibiotic resistance in aquaculture systems. Nanotechnology has emerged as a promising tool for biomedical applications to treat diseases. Shine et al. (2020) explored the antimicrobial potential of Parkia biglobosa-mediated gold nanoparticles, which effectively inhibited the growth of some clinical isolates. Another study by Cai et al. (2016) explored the potential of novel antimicrobial peptides in aquaculture disease management.

7. To effectively combat antibiotic resistance, we must recognize it as both an environmental concern and a challenge related to livestock and wildlife. Integrating the One Health approach into the public health system is crucial for effectively addressing the emergence and spread of antibiotic-resistant bacteria and resistance genes (Ajayi et al., 2024)

By adopting these strategies, aquaculture can move towards a more sustainable and responsible approach to antibiotic use, reducing the risk of antibiotic resistance in fish and promoting healthier aquatic ecosystems.

Constraints to the Adoption of Antibiotic Resistance Strategies

Although multiple strategies have been proposed to combat antibiotic resistance in aquatic environments, implementing these strategies may differ. However, these strategies face several constraints and challenges that hinder their adoption and effectiveness. There may be limited resources, infrastructure, or the political will to enforce regulations and best practices in some regions. This can lead to inconsistent results and a continued increase in antibiotic resistance. Transitioning away from antibiotics may require investment in infrastructure, research, and the development of new techniques, which aquaculture farmers or aquaculturists may not be able to fund. Rico et al. (2014b) addressed the economic considerations related to reducing antibiotic use in aquaculture. Additionally, the limited availability of alternatives has become a challenge. In some cases, viable alternatives to antibiotics are limited or underdeveloped. This underscores the need for research and innovation to identify and develop effective non-antibiotic disease management strategies (Dangtip et al., 2019).

Lack of awareness and education among fish farmers and aquaculture practitioners is a dwindling factor. Practitioners and farmers may lack knowledge of antibiotic-related issues and alternative strategies. To understand the etiology and pathogenesis of disease outbreaks in an aquaculture setting, it is imperative to know the type of antibiotics to administer and the manufacturer's requirements, such as the effective mode of administration, dosage required, and application time. It is important to recognise that regulatory and political challenges may not adequately address the use of antibiotics in aquaculture in some countries (Cabello,2006). One of the constraints that has gained prominence is the persistence of microbial resistance in aquaculture. Several studies investigated the resistant traits in isolated microbes. Genes responsible for antibiotic resistance may continue to circulate in bacterial populations and the environment, thus posing ongoing challenges (Ma et al., 2019).

Addressing these constraints requires collaborative efforts among governments, industry stakeholders, researchers, and policymakers. Strategies to promote responsible antibiotic use and alternative disease management practices must consider economic, educational, regulatory, and cultural factors influencing adoption.

1.12. Conclusion and Future Outlook

Fish products are of great economic value and provide important nutrients. Against this background, aquaculture farmers have shifted from traditional fish-rearing methods to more intensive methods. However, the increasing incidence of bacterial transmission during intensive fish farming is a concern. Aquaculture is a contributing factor in spreading bacteria, as has been made evident in the majority of the studies analyzed. Although antibiotics are effective in the treatment of bacterial infections, surprisingly, it is evident that the isolates obtained are resistant to the most commonly used antibiotics (colistin, ampicillin, cefotaxime, streptomycin, meropenem, tetracycline, sulfamethoxazole/trimethoprim and nalidixic acid) as reported in most of the literature reviewed.This calls for immediate actions to reduce the growing risk of antibiotic resistance.

Although numerous studies have investigated multidrug resistance in many cultured fish there has not been a promising proposal to curb microbial antibiotic resistance. Against this background, we outline the following recommendations that would be valuable in curbing the issues of microbial resistance to boost modern aquaculture practices:

1. Diversifying intensive farming methods to limit or prevent the spread of bacteria is pertinent and should be an area of research interest.

2. Understanding disease development in aquaculture is crucial. This understanding is essential, as some bacteria may originate from fish feed, enabling accurate administration of the appropriate antibiotic dosage.

3. Model studies to understand the cellular activity of most antibiotic drugs have shown that antibiotic and bacterial membrane interactions observed in vitro do not occur in the same way in physiological environments. Due to the complexities and uncertainties that exist during the transition from in vitro to in vivo with the regularly used mode of antibiotic administration, it would be valuable

to strategically develop a paradigm that can decipher the in vitro efficacy of antibiotics, has the capacity to accurately predict their physiological consequences in vivo, and can kill bacteria without developing any resistance, such as nanotechnology.

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CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

AUTHOR CONTRIBUTIONS

Supervision: E.D.A.Writing, review & editing: E.D.A., E.O., E.Y. All authors approved the final draft.

ETHICAL STATEMENTS

Local Ethics Committee Approval was not obtained because experimental animals were not used in this study.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable for the present study as no new data was created or analyzed.

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ACKNOWLEDGEMENT

In this section, those who help to the conduct the study apart from financial support, are indicated.

Example: The authors thank Ahmet Taş (Isparta University of Applied Sciences, Turkey) for his helps during the laboratory part of the study.

FUNDING

In this section, institutions that provide financial support to the conduct of the study are indicated using the grant number.

Example-1: This study was supported by the Scientific Research Projects Coordination Unit of Isparta University of Applied Sciences grant 3241-E2-14.

Example-2: No financial support was received for the present study.

CONFLICT OF INTEREST

Conflicts of interest of the author(s), if any, are indicated in this section.

Example: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

AUTHOR CONTRIBUTIONS

The contributions of each author to the relevant stages of the study are indicated by using each work package and the first letters of the name and surname.

Example:
Fiction: IT; Literature: KL, TN; Methodology: CT, FU; Performing the experiment: FM, CT, FU; Data analysis: FU, TA; Manuscript writing: CT, FU, Supervision: CT. All authors approved the final draft.

ETHICAL APPROVAL STATEMENTS

The ethics committee approvals obtained for the study are indicated with information of institute, date, and number. Manuscripts that are not declare, although they require the Local Ethics Committee Approval in studies conducted with vertebrates, and the Approval for Ethics Committee Approval of Non-Interventional Investigates in survey/interview studies will not be considered for scientific evaluation.

Example-1: Local Ethics Committee Approval was not obtained because experimental animals were not used in this study.

Example-2: This study was conducted with the approval of Animal Experiments Local Ethics Committee of Isparta University of Applied Sciences (Date: 01.07.2010, No: 21438139-147).

DATA AVAILABILITY STATEMENT

In this section, data availability statement should be declared by the authors regarding the anonymous availability of the data used in the manuscript. Acta Aquatica Turcica encourages authors to share research data used.

Example-1: The data that support the findings of this study are openly available in Figshare at https://doi.org/10.6084/m9.figshare.11815566.v1

Example-2: The data used in the present study are available upon request from the corresponding author. Data is not available to the public due to privacy or ethical restrictions.

Example-3: Data supporting the findings of the present study are available from the corresponding author upon reasonable request.

Example-4: Data sharing is not applicable for the present study as no new data was created or analyzed.

Example-5: Research data is not shared.

Example-6: Data supporting the findings of the present study are available in the supplementary material to this article.

CITATIONS

Citations are written in the following formats, in the order of the year, separated by a semicolon (;).

- Single author

(Author, Year)

-- It is thought to be … (Küçük, 2008; Güçlü, 2018a; Güçlü, 2018b).

-- According to Küçük (2008), …

- Two authors

(Author-1 and Author-2, Year)

-- They are among the important parameters (Küçük and Güçlü; 2001; Ekici and Koca, 2021a; Ekici and Koca, 2021b).

-- According to Ekici and Koca (2021b),…

- Three or more authors

(Author-1 et al., Year)

-- It can be repeated periodically (Yiğit et al., 2006a; Yiğit et al., 2006b; Boyacı et al., 2020).

-- According to Boyacı et al. (2020),…

REFERENCES LIST

References should be indented 1.25 cm from the second line and should prepared according to APA version 7. Ideally, the names of all authors should be provided. Usage of "et al" in long author lists (more than 10) will also be accepted. Except for special uses, only the first letter of the title of all references should be capitalized, and all words in the names of the sources (journal, publishing house and congress) should be written with a capital letter.

1-Journal articles

The name of the journal (italic) without shortening, volume (italic), issue, page numbers and DOI number having an active link should be specified.

Petrauskienė, L., Utevska, O., & Utevsky, S. (2009). Can different species of medicinal leeches (Hirudo spp.) interbreed? Invertebrate Biology, 128(4), 324-331. https://doi.org/10.1111/j.1744-7410.2009.00180.x

Wagenaar, D. A., Hamilton, M. S., Huang, T., Kristan, W. B., & French, K. A. (2010). A hormone-activated central pattern generator for courtship. Current Biology, 20(6), 487-495. https://doi.org/10.1016/j.cub.2010.02.027

2-Book

The title of book should be written in italic, and it should be followed with Publisher information.

Nesemann, H., & Neubert, E. (1999). Annelida, Clitellata: Branchiobdellida, Acanthobdellea, Hirudinea. Spektrum Akademischer Verlag.

Sawyer, R. T. (1986). Leech biology and behavior. Oxford University Press.

3-Book section

The title of the chapter should be normal, the title of the book should be in italic, the editor(s), the page numbers of the section, the publisher and the DOI number (if available) having active link should be included.

Le Couteur, D., Kendig, H., Naganathan, V., & McLachlan, A. (2010). The ethics of prescribing medications to older people. In S. Koch, F. M. Gloth, & R. Nay (Eds.), Medication management in older adults (pp. 29-42). Springer. https://doi.org/10.1007/978-1-60327-457-9_3

McCormack, B., McCance, T., & Maben, J. (2013). Outcome evaluation in the development of person-centred practice. In B. McCormack, K. Manley, & A. Titchen (Eds.), Practice development in nursing and healthcare (pp. 190-211). John Wiley & Sons.

4-Web pages / Online documents

The title of the page should be in italic, the name of the website and the active link to the page should be specified.

International Union for Conservation of Nature. (2010). Chondrostoma nasus. https://www.iucnredlist.org/species/4789/97800985

Wikipedia. (2021). Toxicology. https://en.wikipedia.org/wiki/Toxicology

5-Dissertations/Thesis

The title of the dissertation/thesis should be in italic, its type (Doctoral, Master's, Specialization in Medicine) and the name of the university should be specified.

Filik, N. (2020). Inhibition effect of phenolic compounds on the environmental sensing system of Aeromonas hydrophila strains isolated from cultured fish and determination of the clonal relationship between strains by pulsed field gel electrophoresis method. [Doctoral dissertation, Isparta University of Applied Sciences].

Ozdal, A. M. (2019). Effects on growth and coloration of red pepper supplementation as pigment sources to diets of jewel cichlid (Hemichromis guttatus). [Master's thesis, Isparta University of Applied Sciences].

6-Conference, symposium presentations

Event date, presentation title (italic), presentation type (Oral presentation, Poster presentation), event name, city and country should be given.

Ceylan, M., Çetinkaya, O. (2017, October 4 - 6). Assessment of population structure and size of medicinal leech Hirudo verbana, inhabiting some model wetlands of Turkey [Oral Presentation]. International Symposium on Limnology and Freshwater Fisheries, Isparta, Turkey.

Snoswell, C. (2016, October 31 - November 3). Models of care for store-and-forward teledermatology in Australia [Poster presentation]. 7th International Conference on Successes and Failures in Telehealth, Auckland, New Zealand.

NOTE: Manuscripts that are not prepared in accordance with the journal writing rules will not be considered for scientific evaluation.

Yazım Kuralları

SAYFA BOYUTU
Sayfa A4 (21 cm x 29,7 cm) formatında olmalıdır.

KENAR BOŞLUKLARI
Üst: 2,5 cm Sol: 2,5 cm Alt: 2,5 cm Sağ: 2,5 cm Cilt payı: 0 cm

YAZI STİLİ
Yazı karakteri : Times New Roman
Yazı karakteri büyüklüğü : 12 punto
Paragraf : İki yana yaslı
Paragraf girintisi : 1,25 cm
Satır aralığı : 2
Satır numarası : Metnin tümünde satır numarası atanmalıdır
Sayfa numarası : Sayfaların altına gelecek şekilde otomatik numaralanmış

BAŞLIK SAYFASI
Başlık sayfası, makale dosyasından ayrı olarak sisteme yüklenmelidir. Başlık sayfasında sadece aşağıdaki bilgiler yer almalıdır.

- Başlık
Başlık kısa, bilgilendirici ve çalışmayı net olarak yansıtmalıdır. Kısaltma ve formül kullanımı önerilmez.

- Kısa başlık
Başlığı yansıtacak şekilde maksimum 75 karakterde kısa bir başlık verilmelidir.

- Yazarlar
Yazarların ad ve soyadları kısaltılmadan açık olarak yazılmalıdır. Makale yüklenmeden önce yazar isimlerinin doğruluğu kontrol edilmelidir.

- Kurum bilgisi
Kullanılan düzen: Üniversite/Enstitü, Fakülte, Bölüm, İl-ÜLKE
Örnek: Isparta Uygulamalı Bilimler Üniversitesi, Eğirdir Su Ürünleri Fakültesi, Su Ürünleri Yetiştiriciliği Bölümü, Isparta-TÜRKİYE

- Sorumlu yazar
Makalenin tüm aşamalarından sorumlu olacak sorumlu yazar belirtilmelidir. Başlık sayfasında sorumlu yazarın iletişim bilgileri ve posta adresi verilmelidir.
*Sorumlu Yazar: Adı Soyadı, e-posta: …

- ORCID bilgileri
Tüm yazarların ORCID bilgileri belirtilmelidir. Lütfen ORCID tanımlaması yapmak için https://orcid.org adresini ziyaret ediniz.

MAKALE FORMATI
Araştırma makalesi, kısa makale, olgu sunumu ve derlemeler aşağıdaki formata uygun olarak hazırlanmalıdır.

<table>
<tr><th>Araştırma Makalesi</th><th>Kısa Makale</th><th>Olgu Sunumu</th><th>Derleme</th></tr>
<tr><td colspan="4">Başlık
Kısa başlık
Yazarlar
Kurum bilgileri
Sorumlu yazar e-posta adresi
ORCID bilgileri</td></tr>
<tr><td colspan="4">Başlık
Özet
Anahtar kelimeler</td></tr>
<tr><td colspan="4">Title
Abstract
Keywords</td></tr>
<tr><td colspan="4">1. Giriş</td></tr>
<tr><td rowspan="2">2. Materyal ve Metot
3. Bulgular
4. Tartışma
5. Sonuç</td><td>2. SERBEST İÇEREİK</td><td>2. Olgu Sunumu</td><td>2. SERBEST İÇEREİK</td></tr>
<tr><td colspan="3">3. Tartışma
4. Sonuç</td></tr>
<tr><td colspan="4">Teşekkür
Finans
Çıkar Çatışması Beyanı
Yazar Katkıları
Etik Onay Beyanı
Veri Kullanılabilirlik Beyanı
Kaynaklar</td></tr>
</table>

ÖZET

Özet, çalışmanın amacını, kullanılan metotları, öne çıkan bulguları ve literatüre katkısını öz bir şekilde içermelidir. Hem Türkçe hem de İngilizce dillerinde maksimum 300 kelime olacak şekilde yazılmalıdır.

Not: Türk olmayan yazalar için Türkçe Özet desteği sağlanmaktadır.

ANAHTAR KELİMELER

Anahtar kelimeler başlıkta yer almayan, çalışmayı yansıtacak kelimelerden seçilmelidir. En az 3 (üç), en çok 5 (beş) kelime belirtilmeli; kelimeler aralarında virgül (,) son kelimeden sonra ise nokta (.) gelmelidir.

Anahtar kelimeler: CITES, akuaponik, üretim protokolü, mortalite, immünoloji.

ONDALIK GÖSTERİM

Türkçe makalelerde “,” (virgül) İngilizce makalelerde ise “.” (nokta) olmalıdır.

Türkçe: %10,25

İngilizce: 10.25%

LATİNCE GÖSTERİM

Tür ismi, metinde ilk geçtiği yerde kısaltılmadan (Cyprinus carpio), sonrasında ise cinsi ismi kısaltılarak (C. carpio) verilmelidir.

TABLOLAR

Tablo başlığı, tablonun üstüne gelecek şekilde kısa ve öz olmalıdır. Tabloda yer alan kısaltmalar tablonun altında açıklanmalıdır. Tablo özel bir tasarım uygulanmamış, düz kılavuz şeklinde olmalıdır. İhtiyaç bulunması halinde tablo içi metinde yazı karakteri büyüklüğü 10 puntoya kadar düşürülebilir. Tablolara metin içinde Tablo 1, Tablo 2, … şeklinde atıf yapılmalıdır. Tablolar, alıntılandıkları yere en yakın yerde verilmelidir.

Tablolar düzenlenebilir olmalıdır. Ekran görüntüsü veya resim formatındaki tablolar kabul edilmemektedir.

ŞEKİLLER
Şekil başlığı, şeklin altına ortalanmış olarak kısa ve öz olmalıdır. Şekiller minimum 300 DPI çözünürlükte olmalıdır. Şekillere metin içinde Şekil 1, Şekil 2, … şeklinde atıf yapılmalıdır. Şekiller, alıntılandıkları yere en yakın yerde verilmelidir.

TEŞEKKÜR
Bu bölümde finansal destek dışında çalışmanın yürütülmesine katkı sunanlar belirtilir.

Örnek: Yazarlar çalışmanın laboratuvar bölümünde yardım eden Ahmet Taş'a (Isparta Uygulamalı Bilimler Üniversitesi, Türkiye) teşekkür etmektedir.

FİNANS
Bu bölümde çalışmanın yürütülmesine finansal destek sağlayan kurumlar destek numarası kullanılarak belirtilir.

Örnek-1: Bu çalışma 3241-E2-14 proje numarası ile Isparta Uygulamalı Bilimler Üniversitesi Bilimsel Araştırma Projeleri Koordinasyon Birimi tarafından desteklenmiştir.

Örnek-2: Bu çalışmanın yürütülmesinde herhangi bir finans desteği alınmamıştır.

ÇIKAR ÇATIŞMASI BEYANI
Bu bölümde yazarların varsa çıkar çatışmaları belirtilir.

Örnek: Yazarlar, bu çalışmayı etkileyebilecek finansal çıkarlar veya kişisel ilişkiler olmadığını beyan eder.

YAZAR KATKILARI
Bu bölümde isim ve soy ismin ilk harfleri kullanılarak yazarların çalışmanın ilgili aşamalarına yaptıkları katkılar belirtilir.

Örnek:
Kurgu: BT; Metodoloji: CT, FU; Deneyin gerçekleştirilmesi: FM, CT, FU; Veri analizi: FU, TA; Makale yazımı: CT, FU, Denetleme: CT. Tüm yazarlar nihai taslağı onaylamıştır.

ETİK ONAY BEYANI
Bu bölümde çalışmanın yürütülmesinde alınan etik kurul onayının alındığı kurum, tarih ve numarası belirtilir. Omurgalı hayvanlarla yürütülen çalışmalarda Yerel Etik Kurul Onayı, anket/mülakat çalışmalarında ise Girişimsel Olmayan Araştırmalar Etik Kurulu Onayı gerektirdiği halde beyan edilmeyen makaleler bilimsel değerlendirmeye alınmamaktadır.

Örnek-1: Bu çalışmada deney hayvanları kullanılmaması nedeniyle Yerel Etik Kurul Onayı alınmamıştır.

Örnek-2: Bu çalışma Isparta Uygulamalı Bilimler Üniversitesi Hayvan Deneyleri Yerel Etik Kurul onayı ile yürütülmüştür (Tarih: 01.07.2010, No: 21438139-147).

VERİ KULLANILABİLİRLİK BEYANI
Bu bölümde makalede kullanılan verilerin anonim kullanılabilirliğine ilişkin beyanda bulunulmalıdır. Acta Aquatica Turcica dergisi, yazarları araştırma verilerini paylaşmaya teşvik etmektedir.

Örnek-1: Bu çalışmada kullanılan veriler Figshare platformunda ttps://doi.org/10.6084/m9.figshare.11815566.v1 DOI adresi ile erişime açıktır.

Örnek-2: Bu çalışmada kullanılan verilere ilgili yazardan talep üzerine erişilebilir. Veriler, gizlilik veya etik kısıtlamalar nedeniyle kamuya açık değildir.

Örnek-3: Bu çalışmada kullanılan veriler makul talep üzerine ilgili yazardan temin edilebilir.

Örnek-4: Bu çalışmada yeni veri oluşturulmadığı veya analiz edilmediği için veri paylaşımı bu makale için geçerli değildir.

Örnek-5: Araştırma verileri paylaşılmaz.

Örnek-6: Bu çalışmada kullanılan veriler bu makalenin ekinde mevcuttur.

ATIFLAR

Atıflar yıl sırasına göre ve aralarında noktalı virgül (;) olacak şekilde aşağıdaki formatlarda yazılır:

- Tek yazar:
(Yazar, yıl)
-- … olduğu düşünülmektedir (Küçük, 2008; Güçlü, 2018a; Güçlü, 2018b).
-- Küçük (2008)'e göre …

- İki yazar:
(Yazar-1 ve Yazar-2, yıl)
-- … önemli parametreler arasında yer almaktadır (Küçük ve Güçlü; 2001; Ekici ve Koca, 2021a; Ekici ve Koca, 2021b).
-- Ekici ve Koca (2021b)'a göre …

- Üç ve daha çok yazar:
(Yazar vd., yıl)
-- … dönemsel olarak tekrarlayabilmektedir (Yiğit vd., 2006a; Yiğit vd., 2006b; Boyacı vd., 2020)
-- Boyacı vd. (2020)'e göre …

KAYNAKLAR

Kaynaklar APA 7. versiyona göre yazılmalıdır. Tüm yazarların isimleri verilmelidir, ancak 10. yazardan sonra "vd." kısaltması da kabul edilmektedir. Özel kullanımlar hariç olmak üzere tüm eser türlerinde eser isminin sadece ilk harfi büyük, eserin yayınlandığı veya sunulduğu dergi, yayınevi, kongre isimlerinde geçen tüm kelimeler büyük harfle başlanarak yazılmalıdır.

1-Makale

Dergi ismi kısaltılmadan (italik), cilt (italik), sayı, sayfa numaraları ve aktif link içerecek şekilde DOI numarasına yer verilmelidir:

Petrauskienė, L., Utevska, O., & Utevsky, S. (2009). Can different species of medicinal leeches (Hirudo spp.) interbreed? Invertebrate Biology, 128(4), 324-331. https://doi.org/10.1111/j.1744-7410.2009.00180.x

Wagenaar, D. A., Hamilton, M. S., Huang, T., Kristan, W. B., & French, K. A. (2010). A hormone-activated central pattern generator for courtship. Current Biology, 20(6), 487-495. https://doi.org/10.1016/j.cub.2010.02.027

2-Kitap

Kitap başlığı italik olacak şekilde ve yayın kuruluş ismi olacak şekilde verilmelidir.

Nesemann, H., & Neubert, E. (1999). Annelida, Clitellata: Branchiobdellida, Acanthobdellea, Hirudinea. Spektrum Akademischer Verlag.

Sawyer, R. T. (1986). Leech biology and behavior. Oxford University Press.

3-Kitap bölümü

Bölüm başlığı normal, kitap başlığı italik olacak şekilde, editör(ler), bölümün sayfa numaraları, yayıncı kuruluş ve varsa aktif link içerek şekilde DOI numarasına yer verilmelidir:

Le Couteur, D., Kendig, H., Naganathan, V., & McLachlan, A. (2010). The ethics of prescribing medications to older people. In S. Koch, F. M. Gloth, & R. Nay (Eds.), Medication management in older adults (pp. 29-42). Springer. https://doi.org/10.1007/978-1-60327-457-9_3

McCormack, B., McCance, T., & Maben, J. (2013). Outcome evaluation in the development of person-centred practice. In B. McCormack, K. Manley, & A. Titchen (Eds.), Practice development in nursing and healthcare (pp. 190-211). John Wiley & Sons.

4-Web sitesi

Sayfa başlığı italik, websitesinin ismi ve sayfanın aktif linki olacak şekilde verilmelidir.

International Union for Conservation of Nature. (2010). Chondrostoma nasus. https://www.iucnredlist.org/species/4789/97800985

Wikipedia. (2021). Toxicology. https://en.wikipedia.org/wiki/Toxicology

5- Tezler

Tez başlığı italik olacak şekilde, tez türü (Doktora, Yüksek lisans, Tıpta Uzmanlık) ve üniversite ismi belirtilmelidir.

Filik, N. (2020). Kültür balıklarından izole edilen Aeromonas hydrophila suşlarında fenolik bileşenlerin çevreyi algılama sistemi üzerine inhibisyon etkisi ve suşlar arasındaki klonal ilişkinin pulsed field jel elektroforez yöntemiyle belirlenmesi [Doktora tezi, Isparta Uygulamalı Bilimler Üniversitesi].

Özdal, A. M. (2019). Effects on growth and coloration of red pepper suplementation as pigment sources to diets of jewel cichlid (Hemichromis guttatus) [Yüksek lisans tezi, Isparta Uygulamalı Bilimler Üniversitesi].

6- Konferans, sempozyum sunumları

Etkinlik tarihi, sunu başlığı (italik), sunum türü (Sözlü sunum, Poster sunum), etkinlik adı, şehir ve ülke verilmelidir.

Ceylan, M., Çetinkaya, O. (2017, Ekim 4 - 6). Assessment of population structure and size of medicinal leech Hirudo verbana, inhabiting some model wetlands of Turkey [Sözlü sunum]. International Symposium on Limnology and Freshwater Fisheries, Isparta, Türkiye.

Snoswell, C. (2016, Ekim 31 - Kasım 3). Models of care for store-and-forward teledermatology in Australia [Poster sunum]. 7th International Conference on Successes and Failures in Telehealth, Auckland, Yeni Zelanda.

NOT: Dergi yazım kurallarına uygun olarak hazırlanmayan makaleler değerlendirmeye alınmayacaktır.