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Research Article

The Effect of Rainbow Trout (*Oncorhynchus mykiss* Walbaum, 1792) Cage Culture on Benthic Macrofauna in Kesikköprü Dam Lake*

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Abstract: The aim of this research was to determine the effect of a cage farm with a capacity of about 55 t on the benthic macrofauna in Kesikköprü Dam Lake. At 3 stations (the cage and 15 m and 60 m from the cage) selected for this purpose the abundance and composition of benthic macrofauna were determined for 11 months. The abundance of benthic macrofauna (individuals/m^2) between the stations was statistically significant ($P < 0.05$). The abundance of benthic macrofauna was higher at the cage station than at the other 2 stations, except in April and November. During the research period the lowest number of individuals (937 individuals/m^2) was found at the second station 15 m from the cage in February; and the highest number (14,091 individuals/m^2) was determined at the cage station in December. Members of the class *Pelecypoda* were found at all 3 stations. *Dreissena*, which is a member of the class *Pelecypoda*, was the most dominant benthic organism (54%), followed by *Chrinomus* (30%) and *Tubifex* (11%). At the cage station, while members of the class *Pelecypoda* were found, no members of the classes *Insecta, Oligocheta* or *Crustacea* were found. The highest number of benthic macrofauna genera (7) was found at the station 60 m from the cage in April and November. The lowest number of genera (1) was found at the cage station in July. The results of this study in Kesikköprü Dam Lake reveal that the cage culture has a localizing effect on the abundance and composition of benthic macrofauna.

Key Words: Cage culture, rainbow trout, benthic macrofauna, Kesikköprü dam lake

Kesikköprü Baraj Gölü'nde Bir Kafes İşletmesinde Gökkuşağı Alabalığı (*Oncorhynchus mykiss* Walbaum, 1792) Yetiştiriciliğinin Bentik Makrofauna Üzerine Etkisi

Özet: Bu araştırmada, Kesikköprü Baraj Gölü'nde yaklaşık 55 ton kapasiteli bir kafes işletmesinin alıcı ortamdaki bentik makrofauna üzerine etkisinin belirlenmesi amaçlanmıştır. Bu amaçla seçilen üç istasyonda (kafes, kafesten 15 m ve 60 m uzakta olan) 11 ay süreyle bentik makrofauna bolluğu ve kompozisyonu belirlenmiştir. Bentik makrofauna bolluğu (adet/m^2), istasyonlar arasında istatistiki açıdan önemli seviyede farklılık göstermiştir ($P < 0,05$). Bentik makrofauna bolluğu, Nisan ve Kasım ayları dışında, kafes istasyonunda diğer iki istasyona göre daha yüksek bulunmuştur. Araştırma periyodunca birey sayısı en düşük 937 adet/m^2 ile Şubat ayında kafesten 15 m uzakta seçilen 2. istasyonda, en fazla 14.091 adet/m^2 ile Ekim ayında kafes istasyonunda bulunmuştur. Araştırma periyodunca *Pelecypoda* sınıfı üyelerine üç istasyonda da rastlanmıştır. *Pelecypoda* üyelerinden *Dreissena* araştırmada belirlenen en baskın (% 54) bentik organizma grubu olup, bunu *Chironomus* (% 30) ve *Tubifex* (% 11) izlemiştir. Kafes istasyonunda araştırma periyodunca *Pelecypoda* sınıfı üyelerine rastlanırken, *Insecta, Oligocheata* ve *Crustacea* sınıflarına ait bireylere rastlanmamıştır. Bentik makrofauna cins sayısı, en fazla 7 cins ile Nisan ve Kasım aylarında kafesten 60 m uzakta seçilen istasyonda, en az ise 1 cins ile Temmuz ayında kafes istasyonunda belirlenmiştir. Kesikköprü Baraj Gölü'ndeki araştırma bulguları, kafes işletmesinin, bentik makrofauna bolluğu ve kompozisyonu üzerinde lokalize etkisi olduğunu göstermektedir.

Anahtar Sözcükler: Kafeslerde balık yetiştiriciliği, gökkuşağı alabalığı , bentik makrofauna, Kesikköprü baraj gölü.

Introduction

An important alternative for meeting the food requirements of the rising populations is fish and shellfish. The marine system supplies about 80% of Turkey's fishery products, whereas the remaining 10% is from freshwater systems, and 10% is from rearing. In

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recent years, about 1% of the surface area of dam lakes has been used for cage culture, and in inland water sources rainbow trout culture is dominant (1). Wastes that result from production in cages include uneaten feeds and feces. The increase in organic input caused by such wastes in inland and marine environments could result in changes in the abundance of benthic macrofauna and increases in opportunist species (2-6).

It is reported that in many cage farms in Scotland where salmon fish are cultured, the organic wastes emerging from the farms cause the growth of benthic organisms, but this effect is lost 60 m from the cage. Where organic waste accumulation is dense, opportunist organisms that can tolerate sediments rich in organic substances have been determined (3).

The state of benthic communities in bays where fish are cultured in Ireland has been researched, and it was determined that the number of organism species is 0-12 under the cages, and 50 m from the cage this number varies between 11 and 18. This means that species variety decreased 12% about 30-50 m from the cage (7).

In research carried out at 3 stations at a rainbow trout cage farm in Passage Lake in Canada, it was recorded that benthic macrofauna was rare, and of the benthic organisms, *Chrinomidae* species were found (8).

In research areas in Globokie in Poland, where intensive rainbow trout have been cultured in cages since 1974, it was determined that 88-100% of the benthic macrofauna biomass is made up of *Tubificidae* members (9).

When the species composition and seasonal changes in the benthic macrofauna at 5 stations in Kesikköprü Dam Lake were researched in 1995-1996, individuals of 5 classes (*Pelecypoda*, *Gastropoda, Oligocheata, Insecta* and *Crustacea*) of benthic macrofauna were found. The highest seasonal variations in the benthic organisms were found in October, while the lowest were found in September. *Chrinomidae* larva were found almost in every month and at every station. It was determined that the lake is oligotrophic with an average 567.9 ind/m^2 abundance and 1.25 ind/m^2 biomass values (10).

In research on the effects of rainbow trout cage culture on benthic fauna, members of *Gastropoda, Oligocheata, Diptera* and *Crustacea* were found. The variation of benthic macrofauna abundance (ind/m^2) in some months depending on the stations was statistically significant ($P < 0.05$). Benthic macrofauna abundance was high at cage stations in all months, and the highest value was recorded in August (7,445 ind/m^2). Members of *Gastropoda* and *Oligocheata* were found at all stations in every month, and the rate of *Diptera* (*Chrinomidae* sp.) at the cage station was higher in April (11).

At Kesikköprü Dam Lake there are 5 rainbow trout cage farms of 30-55 t capacity. In this research, our purpose was to determine the possible effects of a cage fish farm with a capacity of 55 t on the abundance and composition of benthic macrofauna.

Materials and Methods

Kesikköprü Dam is 110 km southeast of Ankara, 25 km downstream of the Hirfanlı Dam; it was built over the Kızılırmak River in 1966. The dam is at lat 39º 23' N, long 33° 25' E, and it is 785 m above sea level. The lake is of the soil-rock filled type; it has a surface area of 6.50 km^2, and a volume of 95.00 hm^3. It was built for water supply and energy production (12).

The rainbow trout cage farm where the research was conducted started production in 1996. The farm consisted of floating cages, each 5 x 5 x 5 m. The fish were fed on a commercial pelleted diet.

The research was carried out at 3 stations in Kesikköprü Dam Lake. The first station was the cage station; the other 2 stations were in the direction of the flow from Hirfanlı Dam Lake to Kesikköprü Dam Lake, and were 15 m and 60 m, respectively, from the cage (Figure 1). In the selection of the distance between the stations, the principles determined in studies by Brown et al. (4) and Gowen and McLusky (3) were taken into account.

During the research period, the average depth of the stations varied between 27.7 and 27.3 m at the first station, 27.3 and 27.4 m at the second, and 27.7 and 27.8 m at the third.

The research was performed between February and December 2000. In January 2000, the research was stopped due to the bad climatic conditions.

The sediments were sampled with an Ekman grab. Two samples were collected at each station and washed through a series of sieves ranging from 260 to 3360 µ mesh. Benthic macrofauna were identified and counted with the aid of a stereoscopic microscope (13,14).

Statistical analyses were performed using the Minitab and MStat programs for Windows. ANOVA and Duncan's multiple range test were used to evaluate difference in benthos between the stations.

Results

Eight genera of benthic organisms belonging to 5 classes (*Pelecypoda*, *Gastropoda, Oligocheata, Insecta* and *Crustacea*) were identified at 3 stations. Among these organisms, 2 genera belong to the class *Pelecypoda*, 3 belong to the class *Gastropoda*, and 1 belongs to each of the classes *Oligocheata*, *Insecta* and *Crustacea*.

If the annual proportional distribution of the annual total individual numbers (ind/m^2) of the benthic organisms on the basis of stations is examined, 60% of the benthic organisms were found at the first station, 19% at the second, and 21% at the third (Figure 2).

The total annual individual number of identified benthic organisms is 131,270 ind/m^2, and the distribution according to classes is 75.2% *Pelecypoda*, 5.3% *Gastropoda*, 14.9% *Oligocheata*, 4.1% *Insecta* and 0.5% *Crustacea*.

The abundance of benthic macrofauna and the composition according to months and stations are sequentially listed in Tables 1 and 2.

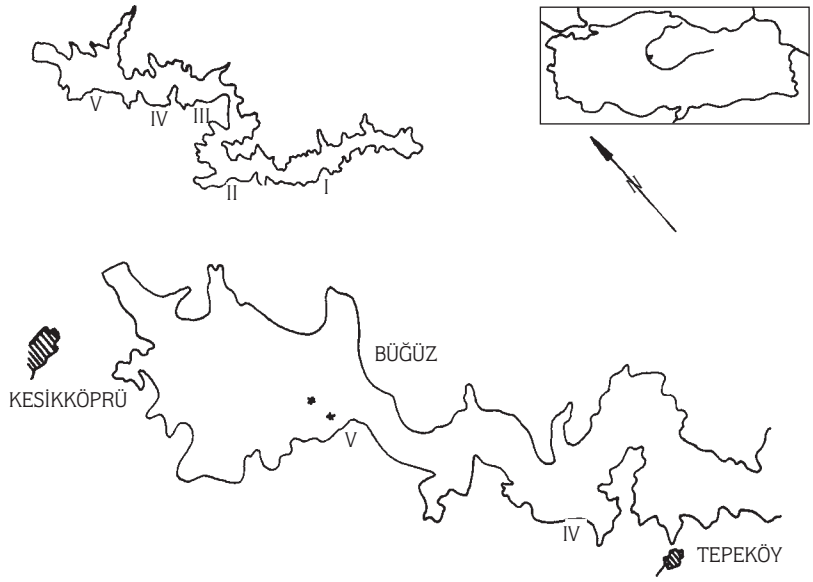

Figure 1. Location of cage trout farms (I, II, III, IV), selected cage farm (V) and stations (*) in Kesikköprü Dam Lake.

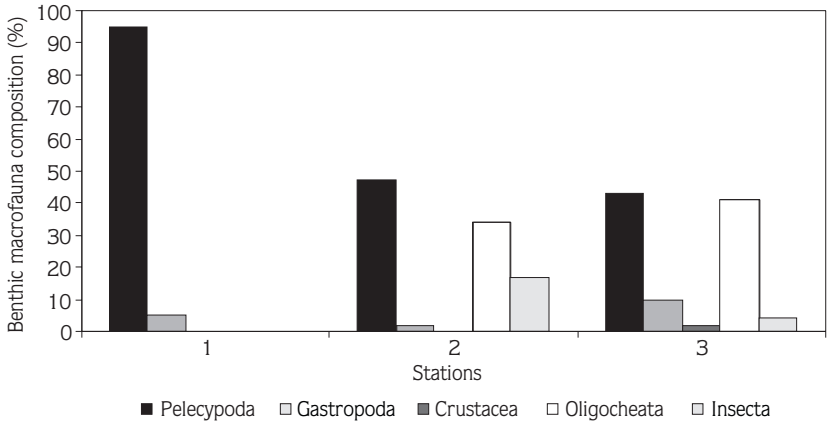

Figure 2. Benthic macrofauna composition (%) at the stations.

Table 1. Abundance of benthic macrofauna (ind/m^2) in stations during the study period (mean ± SE)

MONTH	STATION	MEAN ± SE
	1	8289 ± 155,8 [A]
FEBRUARY	2	937 ± 40,85 [B]
	3	2427 ± 239,45 [C]
	1	6402 ± 264,95 [A]
MARCH	2	1186 ± 30,55 [B]
	3	2230 ± 52,50 [C]
	1	2135 ± 1,65 [A]
APRIL	2	2160 ± 26,40 [A]
	3	4768 ± 120,50 [B]
	1	8971 ± 584,35 [A]
MAY	2	6005 ± 182,70 [B]
	3	2735 ± 64,85 [C]
	1	9571 ± 384,60 [A]
JUNE	2	1233 ± 56,05 [B]
	3	1481 ± 118,85 [B]
	1	6908 ± 735,60 [A]
JULY	2	1509 ± 91,75 [B]
	3	3097 ± 119,70 [B]
	1	7390 ± 209,95 [A]
AUGUST	2	2176 ± 42,75 [B]
	3	1121 ± 34,10 [C]
	1	7849 ± 106,60 [A]
SEPTEMBER	2	1385 ± 215,00 [C]
	3	2259 ± 96,75 [B]
	1	14091 ± 220,40 [A]
OCTOBER	2	3422 ± 133,15 [B]
	3	2590 ± 56,25 [C]
	1	3844 ± 244,40
NOVEMBER	2	2538 ± 49,40
	3	4298 ± 680,20
	1	3302 ± 119,80 [A]
DECEMBER	2	1776 ± 42,25 [B]
	3	1190 ± 98,45 [C]

Differences between means with the same superscripts in a column for each month are statistically significant ($P < 0.05$).

Discussion

It is reported in various studies that there are variations in the biomass, abundance, species variation and number of benthic macrofauna in freshwater and marine systems where fish are cultured in cages (3-5,7,8,11).

In this research, benthic organisms belonging to the classes *Pelecypoda*, *Gastropoda*, *Oligocheata*, *Insecta* and *Crustacea* were found. These findings are similar to those of research that examined the effect of another cage farm in the lake on benthic organisms, which was about the determination of benthic organism genera and seasonal variations in Kesikköprü Dam Lake (10,11).

If the annual proportional distribution of individual numbers of benthic macrofauna determined in our research is taken into account, the cage station ranks first with 60%, followed by the second and third stations. The abundance of benthic organisms was higher at the cage station, except in April and November, and this difference is statistically significant ($P < 0.05$; Table 1). The findings mentioned above are similar to those of research that determined that the abundance of benthic fauna at another cage farm in Kesikköprü Dam Lake with a lower capacity was higher than at other stations (11).

As seen in Table 1, the benthic organism abundance changed seasonally in the lake and the highest number of individuals was found in October (14,091 ind/m^2). It is reported that October is one of the periods in which the individual numbers of benthic fauna in the lake increase (10).

Pelecypoda members have been found in every month at every station. If the distribution of this class according to months and stations is examined, it is seen that the individual number is the highest at the cage station throughout the research. *Dreissena*, which is a member of the class *Pelecypoda*, is the most dominant benthic organism (54%), followed by *Chrinomus* (30%) and *Tubifex* (11%) (Table 2).

At the cage station, no members of the classes *Insecta*, *Oligocheta* and *Crustacea* were found (Fig. 2). In different lakes where rainbow trout fish are cultured in cages, *Chrinomidae* and *Tubificidae* members have been found in high numbers (8,9). It is reported that members of both families are tolerant to organic pollution. The fact that no living groups were found in the mentioned cages could have been resulted from the fact that the second

Table 2. Abundance of benthic macrofauna (ind/m^2) with respect to genus in stations during the study period

		PELECYPODA		GASTROPODA			CRUSTACEA	OLİGOCHAETA	İNSECTA	
Month	Station	*Dreissena* sp.	*Pisidium* sp.	*Physa* sp.	*Planorbis* sp.	*Lymnaea* sp.	*Gammarus* sp.	*Tubifex* sp.	*Chironomus* sp.	Total
	1	7022	-	1178	44	44	-	-	-	8288
February	2	213	-	-	-	-	-	-	724	937
	3	107	35	35	-	-	-	2104	146	2427
	1	6099	-	217	43	43	-	-	-	6402
Marc	2	256	41	-	-	-	-	430	459	1186
	3	530	41	41	41	-	-	1360	217	2230
	1	1956	-	178	-	-	-	-	-	2134
April	2	270	45	-	45	-	-	1170	630	2160
	3	2167	-	607	217	43	43	1300	391	4768
	1	8929	-	42	-	-	-	-	-	8971
May	2	4489	-	-	-	-	-	1415	100	6004
	3	1519	87	-	43	-	-	1086	-	2735
	1	8972	-	342	257	-	-	-	-	9571
June	2	128	43	-	-	-	-	340	722	1233
	3	1070	-	-	-	-	-	370	41	1481
	1	6908	-	-	-	-	-	-	-	6908
July	2	1091	42	42	-	-	-	167	167	1509
	3	2866	-	185	46	-	-	-	-	3097
	1	6655	-	519	173	43	-	-	-	7390
August	2	1043	45	-	-	-	-	680	408	2176
	3	302	129	-	87	-	-	560	43	1121
	1	7717	-	88	44	-	-	-	-	7849
September	2	-	116	-	-	77	-	769	423	1269
	3	256	170	86	-	-	-	1491	256	2259
	1	13697	-	263	131	-	-	-	-	14091
October	2	2267	43	43	43	-	-	855	171	3422
	3	1045	-	92	45	45	-	1363	-	2590
	1	3760	-	84	-	-	-	-	-	3844
November	2	725	453	-	-	-	-	1133	227	2538
	3	1496	192	499	307	-	383	1343	77	4297
	1	3259	-	43	-	-	-	-	-	3302
December	2	228	-	45	137	-	-	1274	91	1775
	3	205	-	123	205	-	123	452	82	1190
Total		97247	1482	4752	1908	295	549	19662	5375	131270

and third stations were in a mud-silt structure and had a soft surface.

During the research period, the numbers of organism genera varied between 1 and 7. The organism composition showed variations between the stations; the highest number of organisms (i.e. 7) was found at the third station, which was 60 m from the cage, in April and November; and the lowest number (i.e. 1) was found at the cage station in July (Table 2).

It is clearly seen that during most of the research period there were differences in the composition as well as an increase in the abundance of benthic macrofauna at the cage station where the research was performed. Therefore, there is a local effect of cage fish culture with such a capacity on benthic organisms within the environment. However, if the fact that there are other cage farms in Kesikköprü Dam Lake and that the recovery of benthic macrofauna might take years are taken into account, the local effects of the farms could be reduced if more attention is given to feeding amount and the type and amounts of stocking, and the rotative use of sites.

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