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Research Article

Feeding Biology of *Silurus glanis* (L., 1758) Living in Hirfanlı Dam Lake

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Abstract: Stomach contents and feeding features of *Silurus glanis* living in Hirfanlı Dam Lake were investigated. Recognizable organisms were found in the stomachs of 91 *Silurus glanis* out of 162 caught between September 1996 and August 1997. The stomach contents of *Silurus glanis* and their levels were as follows: *Gammarus* (21.87%), Odonata (19.79%), *Sander lucioperca* (19.79%), *Tinca tinca* (18.76%), *Silurus glanis* (1.04%) and Gastropoda (1.04%). In addition, it was noted that 1.04% of the organisms found in the stomachs of *Silurus glanis* were Homoptera and 2.08% were the parasite Platyhelminthes.

Key Words: *Silurus glanis*, feeding, stomach contents, Hirfanlı Dam Lake

Hirfanlı Baraj Gölü'nde Yaşayan *Silurus glanis* (L., 1758)'in Beslenme Biyolojisi

Özet: Bu araştırmada Hirfanlı Baraj Gölü'nde yaşayan *Silurus glanis*'in mide içeriği ve beslenme özelliği incelenmiştir. Eylül 1996-Ağustos 1997 tarihleri arasında avlanan 162 adet yayın balığından 91 bireyin midesinde teşhis edilebilen organizmalara rastlanmıştır. Araştırma sonucunda *Silurus glanis*'in mide içeriğini bulunma sıklığına göre, *Gammarus* (% 21,87), Odonata (% 19,79), *Sander lucioperca* (% 19,79), *Tinca tinca* (% 18,76), *Silurus glanis* (% 1,04) ve Gastropoda (% 1,04)'nın oluşturduğu saptanmıştır. Ayrıca, mideden çıkan organizmaların % 1,04'ünde Homoptera ve % 2,08'inde parazit Platyhelminthes'e rastlanmıştır.

Anahtar Sözcükler: *Silurus glanis*, beslenme, mide içeriği, Hirfanlı Baraj Gölü

Introduction

Silurus glanis is an economically valuable fish due to its very tasty flesh and lives in all inland waters of Turkey except for Southeast Anatolia and the southern part of Eastern Anatolia (1).

The local people call it "yayın", "galyanos", "at balık", "karabalık", "gelebicin", "çılpık" or "lök" in different regions (2). Its distribution in Turkey has been investigated by various scientists (3-12), and its features have been widely examined (13-22).

The depletion of land based food stocks forces scientists to consider water-based foods, which are very plentiful in Turkey. The investigation of the feeding behavior of the fish as well as their other features will enable us to utilize them in a much more efficient way. This study concerns the feeding behavior and stomach contents of *Silurus glanis*, which is very suitable for cultured breeding.

Materials and Methods

Hirfanlı Dam Lake was constructed on the Kızılırmak River for energy production purposes in 1959. It stands at an altitude of 856 m and is located 24 km southwest of Kırşehir and 70 km south of Kırıkkale provinces (23,24). A map of the dam lake and the hunting stations is given in Figure 1.

During this study, 162 *Silurus glanis* were caught between September 1996 and August 1997. Fishing was carried out with 100 m trammel nets with 18, 25, 33, 40 and 55 mm inner mesh sizes and fishing hooks. The inner/outer mesh ratio ranged from 0.60 to 0.65. The lengths of the samples were measured on a millimetric plate and they were weighed using a balance with an accuracy of ± 0.1 g. The average lengths and the weights were determined according to age.

The fish were dissected with scalpels in the laboratory and their stomachs were removed. The stomachs were

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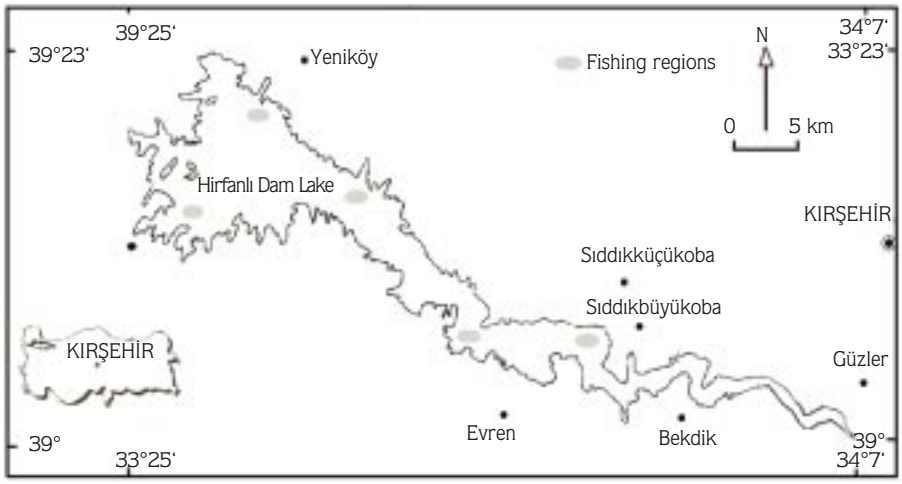

Figure 1. Map of Hirfanlı Dam Lake.

kept in 4% formaldehyde. The ages of the fish were determined from their vertebrae (25,26). The contents of each stomach were classified and counted separately. Small organisms in the stomach were determined by means of the relevant literature (27-32).

The percentage of a certain organism found in the stomachs of the fish was calculated by the formula $F = f \times \frac{100}{n}$. The weight of a recognized small organism in the total weight was found by the formula $W = f \times \frac{100}{W_{total}}$.

The average number of systematically classified organisms among the total number of organisms was computed by means of the formula $S = n \times \frac{100}{S}$ (33,34).

Results

Length and weight distribution according to age

S. glanis individuals were found to range between 0 and 5 years of age. The lengths of the females and males ranged from 22.3 to 52.4 cm and 22.2 to 52.9 cm, respectively. The weight distribution was 68-920 g for females and 63-955 g for males. The male and female individuals at II and III years of age were higher in number compared with the other age groups (Table 1).

Table 1. The weight and length distribution of *S. glanis* individuals living in Hirfanlı Dam Lake according to age.

Age	N	Female		N	Male	
		L (cm) (Min-Max)	W (g) (Min-Max)		L (cm) (Min-Max)	W (g) (Min-Max)
0		-	- 1	18.3	33	
I	11	24 22.3-25.9	769 68-91.7	23	74 22.2-24.1	63-89
II	24	27.9 24.1-32.5	140.9 69-215	28	28 24-35.1	150.3 78-275
III	32	34.2 26.5-38.6	28335 142-370	33.5	264.7 27-39.7	91-390
IV	8	42.4 40.1-45.1	458.8 316-530	5	43.6 41.2-45.3	501.6 418-540
V	5	49.2 45.9-52.4	8464 820-920	50.6	895 48.4-52.4	840-955

The organisms found in the stomachs

The stomachs of 71 *Silurus glanis* out of the 162 were empty. There were undigested and recognizable organisms in the stomachs of the remaining 91 fish.

Table 2 tabulates the cases of full and empty stomachs among the *Silurus glanis* individuals caught during the study.

The stomach contents of the individuals were as follows: *Sander lucioperca* (L., 1758), *Tinca tinca* (L., 1758), Odonata (*Aeshna* sp, *Zygoptera*), Gammarus, Diptera, Gastropoda, Caryophyllaidae and Homoptera. The percentages of the empty and full stomachs are given in Figure 2.

Total weights of stomach contents and weight percentage distribution of the organisms

The weight, numbers and percentages of the organisms observed in the stomachs of the *S. glanis* individuals are listed in Table 3. It was determined that the major portion of the dietary intake of *S. glanis* individuals consists of fish, followed by Odonata and other invertebrate species. Figure 3 shows the number and weight percentages of the various organisms found in the stomachs of *S. glanis* individuals.

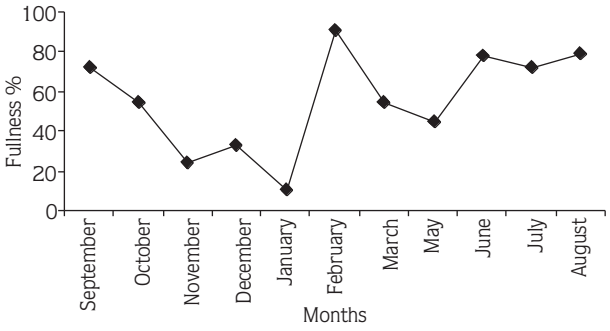

Figure 2. The percentage of full stomachs of the *Silurus glanis* individuals caught in Hirfanlı Dam Lake according to month.

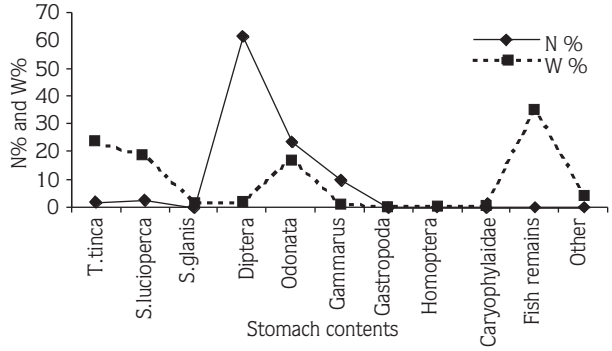

Figure 3. The number and the weight percentage of the food found in the stomachs of *Silurus glanis* individuals.

Table 2. The conditions of the full and the empty stomachs of *Silurus glanis* caught at different times in Hirfanlı Dam Lake.

Date of fishing	Number of fish caught	FULL	%	EMPTY	%
September	18	13	72.22	5	27.78
October	11	6	54.55	5	45.45
November	8	2	25.00	6	75.00
December	6	2	33.33	4	66.67
January	27	3	11.11	24	88.89
February	12	11	91.67	1	8.33
March	20	11	55.00	9	45.00
May	11	5	45.45	6	54.55
June	14	11	78.57	3	21.43
July	11	8	72.73	3	27.27
August	24	19	79.17	5	20.83
TOTAL	162	91	56.17	71	43.83

Total numbers and percentage distribution of the organisms found in the stomachs of *S. glanis*

There were 865 organisms counted in the stomachs of the 162 *S. glanis* investigated. The most abundantly found organism among these is Diptera, counted 532 times (61.50%) followed by Aeshna sp. and Odonata larvae, counted 198 times (22.89%). Zygoptera, another Odonata larva, was counted 3 times (0.34%). Among the fish species the distribution was as follows: *Tinca tinca* 19 counts (2.19%), *Sander lucioperca* 20 counts (2.31%), Gammarus sp. 87 counts (10.05%), Gastropoda 2 counts (0.239%), *S. glanis* one count (0.11%), Homoptera one count (0.11%), and Caryophyllaidae 2 counts (0.239%). Since *S. glanis* is a fish that lives in the benthic region its dietary intake is constituted by the fish and Chironomus larvae living in the same region (Table 3 and Figure 3).

The numbers and percentage distribution of the organisms according to season

The number and percentage distribution of the organisms according to season are given in Table 4 and Figure 4. Summer was when the maximum amount of organisms was found in the stomachs, as was also the case with weight distribution. In winter the variety of the feeding organisms decreased and the most abundant organism in the stomach contents was Gammarus. In autumn diptera individuals dominated the stomach contents and the variety of feeding organisms was lower than in the spring and summer. The variety of the feeding organisms increased in the spring and fish was the most preferred organism for feeding purposes.

The weight and weight percentage distribution of organisms according to season

The weight and weight percentage distribution of the organisms according to season are given in Table 4 and Figure 4. The weight of organisms found in the stomachs in each season revealed that the amount of organisms was at its maximum in the summer and at a minimum in the winter.

The distribution of the total weight and the number of the food found in the stomachs of *S. glanis* individuals according to month

There was 837.22 g of organisms found in the stomachs of 91 *S. glanis* individuals. The total weight and percentage distribution of food according to month is given in Table 5 and Figure 5. The numeric distribution and the numeric percentage of the food according to month were also determined (Table 5 and Figure 6). August is the month when the highest amount of food was taken, at 291.53 g and 613 pieces.

Table 3. The total number, weight and percentage of the organisms encountered in the stomachs of the *Silurus glanis* individuals.

The organisms found in the stomachs	Total number (N)	N%	Total weight of food (g)	Weight percentage
Tinca tinca	19	2.19	193.28	23.09
S. lucioperca	20	2.31	151.11	18.05
S. glanis	1	0.12	10.00	1.19
Diptera	532	61.50	10.26	1.23
Odonata	201	23.24	142.33	17.00
Gammarus	87	10.06	4.27	0.51
Gastropoda	2	0.23	0.28	0.03
Homoptera	1	0.12	0.19	0.02
Caryophyllaidae	2	0.23	1.37	0.16
Fish remains	-	-	291.14	34.78
Other	-	-	32.99	3.94
TOTAL	865	100	837.22	100

Table 4. The total weight, number percentage distribution of the food found in the stomachs of *Silurus glanis* individuals according to season.

Seasons		Spring				Summer				Autumn				Winter				Total	
Number of stomachs		16				38				21				16				91	
		N	N%	W	W%	N	N%	W	W%	N	N%	W	W%	N	N%	W	W%	N	W
Stomach contents	*Tinca tinca*	6	25.00	37.45	23.35	4	0.55	70.00	18.37	3	3.37	31.01	16.53	6	16.66	54.83	50.54	19	193.29
	S. lucioperca	10	41.66	66.92	41.73	2	0.27	22.61	5.93	7	7.86	55.78	29.74	1	2.77	5.8	5.34	20	151.11
	S. glanis	1	4.16	10.00	6.23	-	-	-	-	-	-	-	-	-	-	-	-	1	10.00
	Diptera	-	-	-	-	454	63.40	9.00	2.36	78	87.64	1.35	0.71	-	-	-	-	532	10.35
	Odonata	3	12.5	0.05	3.11	198	27.65	142.28	37.34	-	-	-	-	-	-	-	-	201	142.33
	Gammarus	3	12.5	0.11	6.85	56	7.82	2.85	0.74	-	-	-	-	28	77.77	1.31	1.20	87	4.27
	Gastropoda	-	-	-	-	2	0.27	0.28	7.34	-	-	-	-	-	-	-	-	2	0.28
	Homoptera	1	4.16	0.19	0.11	-	-	-	-	-	-	-	-	-	-	-	--	1	0.19
	Caryophyllaidae	-	-	-	-	-	-	-	-	1	1.12	0.72	0.38	1	2.77	0.65	0.59	2	1.37
	Fish remains	-	-	40.89	25.49	-	-	124.19	32.59	-	-	86.41	46.08	-	-	39.65	36.55	-	291.14

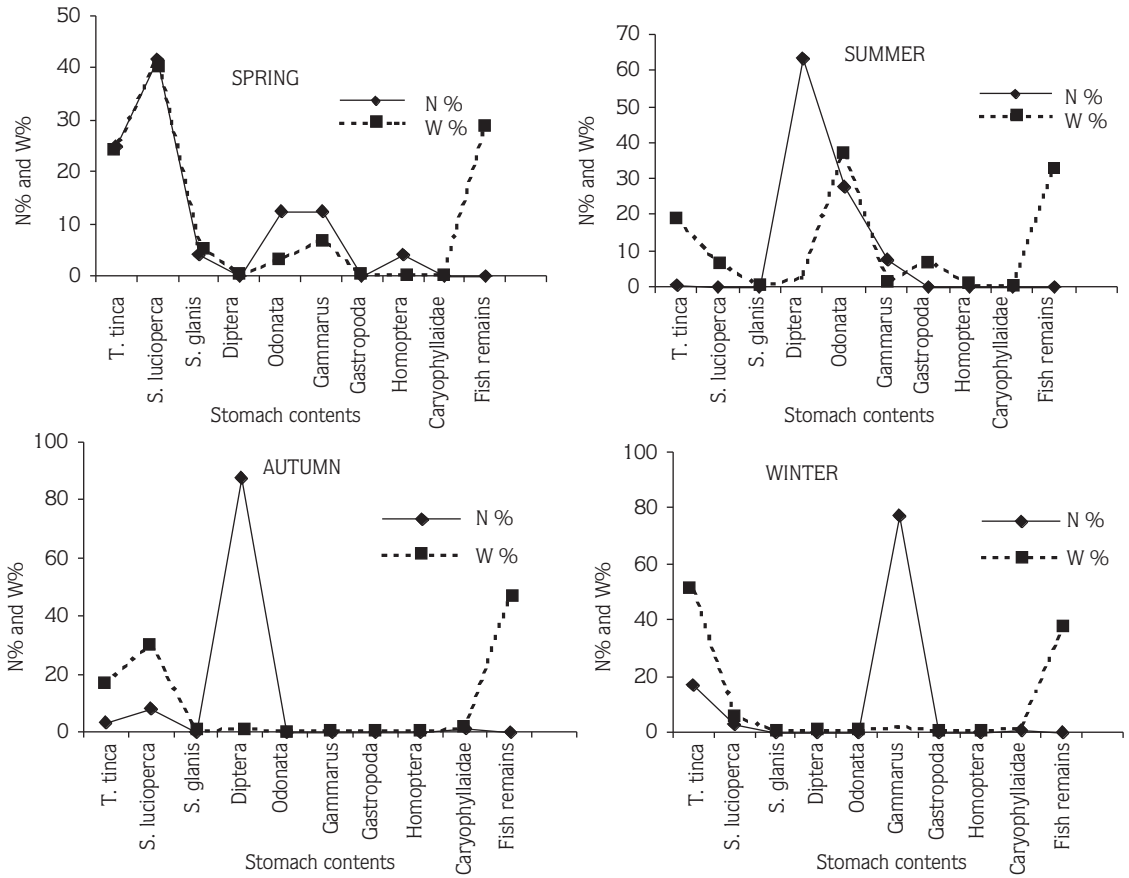

Figure 4. The total weight, number percentage distribution of the food found in the stomachs of *Silurus glanis* individuals according to season.

Table 5. The total weights and weight percentage of the food found in the stomachs of *Silurus glanis* individuals according to month.

Months	Number of stomachs	Total food weight (g)	Percentage distribution of the total food	Average organism weight per *S. glanis* individual (g)	Total number of food	Percentage distribution of the total food	Average organism weight per *S. glanis* individual
September	13	96.11	11.47	7.39	72	8.32	5.53
October	6	60.45	7.22	10.07	15	1.74	2.5
November	2	30.96	3.69	15.48	2	0.23	1.00
December	2	26.51	3.16	13.25	2	0.23	1.00
January	3	32.56	3.93	10.85	3	0.35	1.00
February	11	49.4	5.90	4.49	31	3.58	2.81
March	11	115.85	13.83	10.53	15	1.74	1.36
May	5	44.51	5.31	8.90	9	1.04	1.8
June	11	20.25	2.41	1.84	56	6.47	5.09
July	8	69.19	8.26	8.64	47	5.43	5.87
August	19	291.53	34.82	5.34	613	70.87	32.26
TOTAL	91	837.22	100	-	865	100	60.22

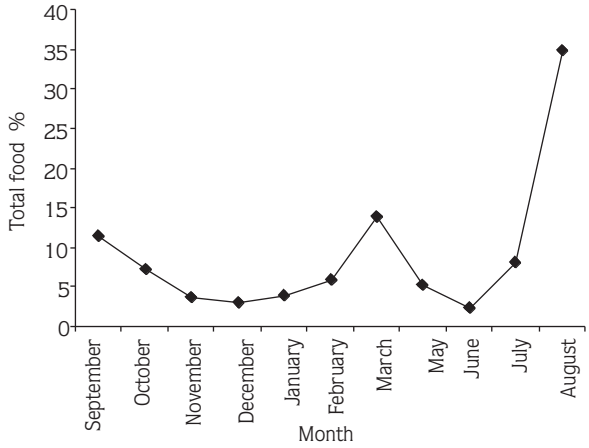

Figure 5. The percentage distribution of the total weight of the food found in the stomachs of *Silurus glanis* according to month.

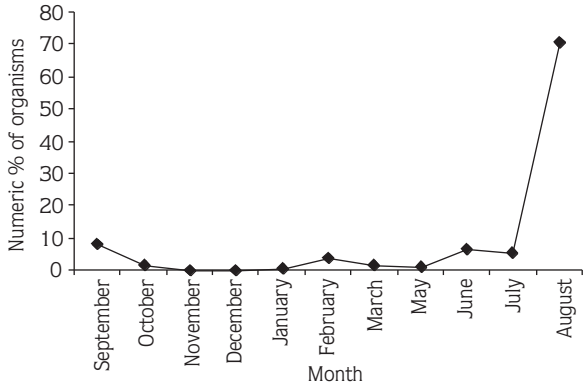

Figure 6. The numeric and percentage distribution of the food found in the stomachs of *Silurus glanis* according to month.

Discussion

The age distribution of the *S. glanis* individuals was between 0 and V years. The average weights and lengths were determined according to ages. The smallest individual was a male at 0 years of age with a length of 18.2 cm and a weight of 33 g. The largest individual was a male at the age of V with a length of 43.4 cm and a weight of 955 g. The number of studies related to the age distribution of *S. glanis* is very limited. Saylar (11) determined that the *S. glanis* individuals in Altınkaya Dam Lake and Kabalar Pond ranged from 0-XV and 0-IX in age, respectively. He indicated that the population density was between I and VII in Altınkaya Dam Lake and between II-V in Kabalar Pond. These values partly correspond to the age distribution of *S. glanis* individuals in Hirfanlı Dam Lake. The fact that no fish were caught at advanced ages may be due to fishing techniques. Average weight and lengths in Altınkaya Dam Lake and Kabalar Pond were higher than those in Hirfanlı Dam Lake. This may be a consequence of the difference in habitats and diversity of feeding organisms.

S. glanis is a carnivorous fish and its infants feed on plankton until 1 year of age. They hide during the day and seek food in shallow places at night (2). They eat small aquatic organisms during their youth and then they mostly feed on fish at later stages (1). During the investigation of the stomachs of *S. glanis* individuals, the percentages of full and empty stomachs were 56.17% and 43.83% (Table 2). The percentage of empty stomachs is highly significant. The highest ratio was observed in January (88.89%). Although stomach fullness ratios were high in February (Table 2 and Figure 2), Table 5 reveals that the level of feeding was low as regards stomach contents. Winter was when the variety of organism as regards the contents of the stomachs was at its lowest level. This shows that the fish is not properly fed. In the fish investigated there were digested and undigested organisms, which were classified at the level of species or family.

The fact that there were *Sander lucioperca* and *Tinca tinca* individuals in particular in the stomachs of *S. glanis* individuals implies that the fish is particular about its food. We had no opportunity to make any comparison since there have been no studies carried out on this subject. Although the Hirfanlı *Cyprinus carpio* is abundantly present in the lake according to stocks (70 t) it was not encountered in any stomach during the year (24).

Tanyolaç and Karabatak (7) investigated the stomach contents of the *S. glanis* individuals in Mogan Lake, and reported that there were *Cyprinus carpio* and *Alburnus escherrichi* in the stomachs of mature individuals at the ages of VII to IX with a length of 79 cm. This shows that *S. glanis* cannot consume carp at early ages.

The organisms found in the stomachs of *S. glanis* individuals in Hirfanlı Dam Lake reached their maximum level in summer as regards number and weight (Table 3). Atay (2) states that *S. glanis* consumes the most food at the end of its breeding period. This study also verifies this hypothesis.

Hirfanlı Dam Lake was first implanted with *S. glanis*, a carnivorous fish living at the bottom. It was then implanted with *Sander lucioperca* to meet the need for a carnivorous fish living at the surface (23,34). The investigation of the feeding behavior of these 2 fishes revealed that the organisms *Gammarus*, Diptera and Odonata are common in their dietary intake (35). This results implies that there will be feeding competition between *Sander lucioperca* and *S. glanis.*

Orlova and Popava (17) studied 911 *S. glanis* individuals living in the Volga river, and found that these feed on invertebrates such as Cladocera, Gammaridae and Chironomidae when their length is in the range 4-7 cm, but that their dietary intake includes various fish and even frogs when they grow older. They reported that food consumption decreased in autumn and the most food intake was seen in fish at the ages of 2 to 4. We reached the same conclusion in this study.

Aydın (10) states that cannibalism starts among *S. glanis* infants when they reach a length of 4-5 cm. Orlova and Popava (17) report that *S. glanis* is a predatory fish like *Sander lucioperca.*

Among the fish investigated in Hirfanlı Dam Lake *S. glanis* was found only in one stomach. The fact that one species of *S. glanis* was found only in the stomach of one individual throughout the year prevents us reaching any definite conclusion about cannibalism. A study over a much more prolonged period will shed light on this issue.

S. glanis is a species that is highly tolerant to a lack of oxygen, high salinity and the turbidity of the water, and it grows very fast (11). Bauch states that *S. glanis* may reach a weight of 50 g in summer and 3000 g at the age of IV. Meske reported that in cultured breeding it might reach a weight of 1270 g (11).

The *S. glanis* population in Hirfanlı Dam Lake is not high in number. Individuals at the ages of IV and V were rarely encountered in the population. This was attributed to the fact that this is a species of high economic value and is consumed by the local people. That is why the adjustment of the mesh size of the nets and control of fishing in the lake are of great importance for increasing the stock in the lake.

Another important finding of the study is that *S. glanis* feeds on economically valuable fish such as *Sander lucioperca* and *Tinca tinca.* We are of the opinion that the number of uneconomical fish should be reduced in the lake for the future of the population of the economically valuable fish.

The investigation of the fish stocks in the Hirfanlı Dam Lake reveals that the *S. glanis* stock in the lake has decreased over the years (23,24). It is thought that the water criteria as well as over-fishing influenced this. Therefore an investigation of the relation between the water criteria and the fish population is necessary. It was observed that the fishermen were fishing every month of the year. Therefore we think that the controlling of illegal fishing is of great importance and the lake should be rented to institutions that are able to carry out this duty on a regular basis. This will ensure the sustainability of the population.

Studies on *S. glanis* in Turkey are very rare. The adaptability of *S. glanis* to adverse conditions, the use of its floating pouch and bones in the glue industry and the use of its caviar for food, increase the economic viability of this species (1,2). The cultured breeding of this species is of great importance for Turkey. It is necessary to investigate the ecological and feeding behavior of *S. glanis*, which occupies an important place among the fresh water fish of the country, in different habitats. These studies will permit the widespread economic utilization of *S. glanis* as an animal based protein source.

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