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RESEARCH ARTICLE

Feeding Ecology of Various Length-Classes of Brown Trout *(Salmo trutta)* in Different Streams of Coruh River, Turkey

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Summary

In the present study, It was investigated a variation in food consumption by brown trout Salmo trutta, of different sizes and streams of Coruh river, Turkey. The diet of 277 brown trout individuals were described for the purpose of registering the number and frequency of prey objects per fish, and their selection of invertebrate fauna by electroshock between August 2008 - July 2009. Samples of invertebrate fauna were also gathered from the stream bottom. Trichoptera was the most abundant organism in all streams for brown trout. The diet of brown trout included 20 types of organisms, with Trichoptera as the most consumed taxa. Each length class of fish consumed different prey taxa. The most important and preferable food item varied among the length classes of the brown trout. In the fish 3-11.9 cm and 12-20.9 cm fed chiefly on Trichoptera *(Limnephilus* sp.), Saltatoria *(Tetrix* sp.) and Trichoptera *(Sericostomata* sp.), respectively. In the fish >21 cm fed on Ephemeroptera *(Epeorus alpicala)*, Diptera *(Simulium* sp.) and Saltatoria *(Tetrix* sp.). In conclusion, this study had shown that brown trout fed on a variety of prey items, and the diet and feeding behaviour changes by habitat and fish size.

Keywords: *Diet composition, Brown trout, Salmo trutta, Length, Coruh River, Turkey*

Çoruh Nehri (Türkiye) Üzerinde Bulunan Farklı Derelerdeki Çeşitli Boy Sınıflarına Ait Alabalıkların Beslenme Ekolojisi

Özet

Bu çalışmada, Çoruh Nehri üzerindeki farklı derelerdeki ve farklı büyüklükteki alabalıklar tarafından tüketilen besinlerdeki değişim incelenmiştir. Ağustos 2008-Temmuz 2009 tarihleri arasında elektroşoker ile avlanan 277 adet alabalık bireyinin besini, her balık başına düşen besin miktarını ve tercih ettikleri omurgasız canlıları belirlemek amacıyla tanımlanmıştır. Aynı zamanda zeminden omurgasız örnekleri de toplanmıştır. Trichoptera, tüm derelerdeki alabalıklar için en bol organizma olmuştur. Alabalıkların besinini, en çok tüketilen takson olarak başta Trichoptera olmak üzere 20 çeşit besin organizması oluşturmuştur. Her boy sınıfındaki balıklar farklı besinleri tüketmişlerdir. En önemli ve en çok tercih edilen besin organizması, değişik boy grubundaki alabalıklar arasında değişim göstermiştir. 3-11.9 cm ve 12-20.9 cm boya sahip alabalıklar başlıca sırasıyla Trichoptera *(Limnephilus* sp.), Saltatoria *(Tetrix* sp.) ve Trichoptera *(Sericostomata* sp.) üzerinde beslenmişlerdir. 21 cm'den büyük alabalıkların besinini ise Ephemeroptera *(Epeorus alpicala)*, Diptera *(Simulium* sp.) ve Saltatoria *(Tetrix* sp.) oluşturmuştur. Sonuç olarak bu çalışma, alabalıkların çeşitli besin maddeleri ile beslendiğini, besin ve beslenme davranışının balık büyüklüğüne ve habitata göre değiştiğini göstermiştir.

Anahtar sözcükler: *Besin kompozisyonu, Alabalık, Salmo trutta, Boy, Çoruh Nehri, Türkiye*

INTRODUCTION

Salmonids are generally considered as opportunists [1] or generalists organism [2] since they are unselective on prey. However, the predatory activity of the brown trout can not be considered simply proportional to the environmental density of the prey, as shown by Ware [3] for rainbow trout.

In salmonids, feeding is accomplished by visual foraging [4]. Three potential groups of brown trout food can be distinguished; substrate-associated prey, suspended drift and surface drift prey. Also, its food sources could be divided into those of terrestrial (invertebrates accidentally falling into streams) and aquatic origin. However, some

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studies do not agree on the diet composition of this fish, i.e. whether it is primarily composed of prey obtained from [5,6] or from benthos [7,8]. Bridcut and Giller [9] demonstrated that trout diet is largely determined by the habitat in which these fish forage.

Since the diet of fish often changes with body size [10,11] and older fish in salmonids, shift their preferences towards larger prey [12]. The aim of the present study was to analyse the possible changes in diet between the different size classes of individuals of brown trout in Coruh River, Turkey. Moreover, it was also to verify the relationship between the availability of potential macrobenthic prey and their actual presence in the diet, and to compare the relative importance index values shown by brown trout of different sizes.

MATERIAL and METHODS

Invertebrate Abundance and Diet Analyses

Brown trout were collected from August 2008 to July 2009. Fish were caught by electrofishing in stream section in 100 m. The theoretical density of individuals of each fish was calculated by Zippin's method [13]. Invertebrate densities were extrapolated to values for one square meter (ind./m²). Fish collected for stomach content analysis were preserved in a plastic bags with ethil alcol solution (70%,v:v). It was examined stomach contents of each fish specimen, determined the number of organisms belonging to each particular taxon, and recorded blot-dry wet weights to the nearest milligram. In the laboratory, stomach contents and benthic invertebrates were identified to the lowest feasible taxonomic unit (usually genus) using the identification keys of Demirsoy [14] and Quigley [15]. Samples of benthic invertebrates were taken by the kick-sampling methods in 0.4 m² areas in three times at each study site. IT was estimated the percent composition by number, as recommended by Bowen [16] to compare the diets of brown trout to in stream invertebrate abundance. Samples were always taken from the shallow section according to width and flow of streams *(Fig. 1)*.

Dietary importance of food categories was determined using the modified relative importance index (IRI, %) according to size. IRI is a compound index composed of the percentage frequency of occurrence (FO, %), percentage by weight (W, %), and numerical percentage (N, %) [17]. All percentages were calculated as follows:

$$N_i\% = \frac{100 * N_i}{\sum_{i=1}^{n} N_i}; FO_i\% = \frac{100 * FO_i}{\sum_{i=1}^{n} FO_i}; W_i\% = \frac{100 * W_i}{\sum_{i=1}^{n} W_i};$$

$$IRI_i = (N_i\% + W_i\%) * FO_i\%$$

$$IRI_i\% = \frac{100 * IRI_i}{\sum_{i=1}^{n} IRI_i};$$

where n is the total number of prey in the examined stomachs, and W_i and N_i are the total wet weight and number of prey, respectively and FO_i is the number of brown trout stomachs containing prey i [17].

The Margalef species richness (d) and Shannon's Diversity (H`) were used to evaluate species composition within and between size groups [18]. Margalef species richness was calculated as:

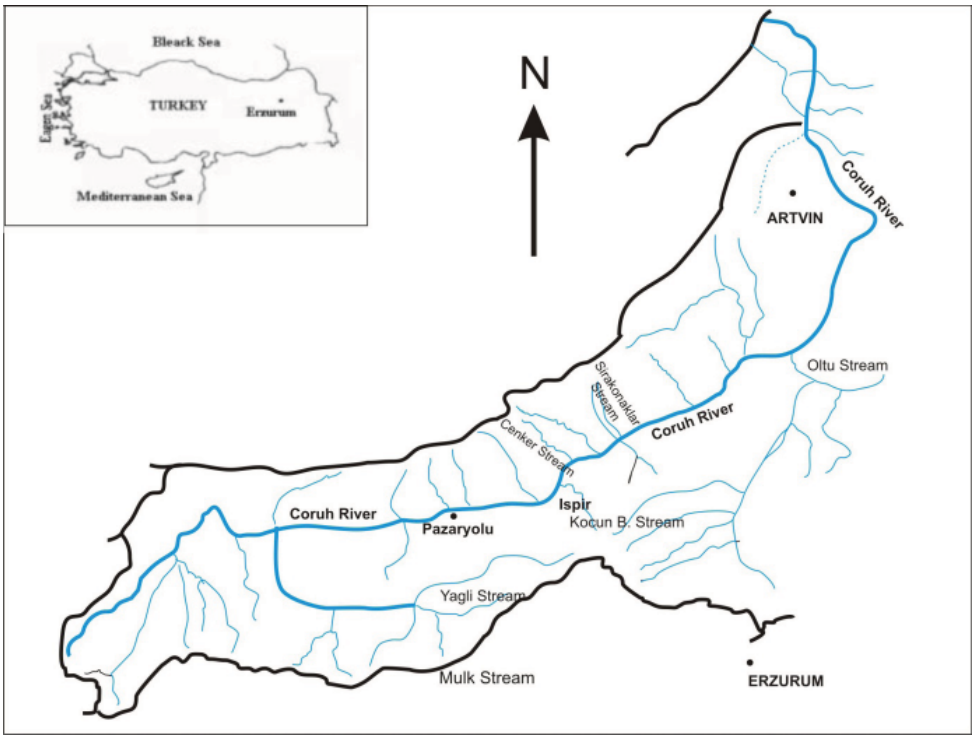

Fig 1. Map of studied streams in Coruh River

Şekil 1. Çoruh Nehrinde çalışılan derelerin haritası

$$D=\frac{(S-1)}{(LogN)}$$

where S is the number of species and N is the number of specimens. Shannon's diversity was calculated as:

$$H`=-\sum_{i=1}^{i=S}(Pi * Log_e Pi)$$

where P is the ratio of species *i* [19]. The use of the Shannon-Wiener index provides an objective indication of niche breadth [20]. Low values indicate diets with few prey items (specialist predators) and high values indicate generalist diets. The data of invertebrate of fish stomach were used to develop a bray-curtis similarity matrix with Primer software.

RESULTS

Invertebrate Abundance

The mean abundance of invertebrates in the studied streams was 1478 ind./m² and min and max values ranged from 518 ind./m² in the Sirakonaklar stream to 2756 ind./m² in the Cenker stream *(Fig. 2)*. Trichoptera, Coleoptera, Ephemeroptera and other organisms were the most abundant invertebrate groups *(Fig. 3)*. The composition of invertebrates did not differ significantly among the streams (P>0.05).

Analysis of Brown Trout Diet

A total of 3116 prey items were detected in trout stomachs. The analysis showed that brown trout consumed a wide diversity of food items *(Fig. 4)*. The occurrence of Trichoptera in brown trout diet was higher (64%) than those of the others. The latter component of the fish diet mainly consisted of Diptera, Saltatoria and Ephemeroptera.

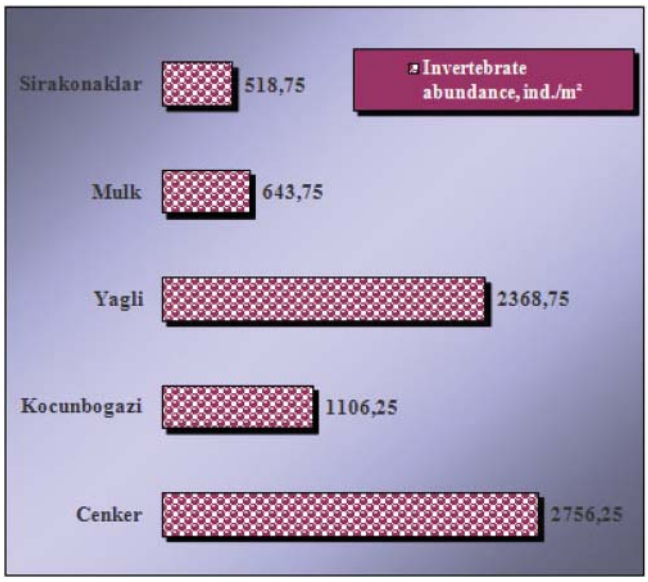

Fig 2. Invertebrate abundance in studied streams in Çoruh River (ind./m²)

Şekil 2. Çoruh Nehrinde çalışılan derelerdeki omurgasız canlı bolluğu (ind./m²)

Limnephilus sp. from Trichoptera detected in 77% of the brown trout stomach examined, proved to be the most frequent prey of brown trout. The prey composition of brown trout, which mainly consisted of ten components, was quite different in all the streams.

Variation in the Diet by Size of the Fish

Table 1 shows a size-dependent variation in IRI% of the most important food items in the stomachs. Trichoptera was mainly eaten by the individuals in all length groups, while Saltatoria *(Tetrix* sp.) was dominant food item in the length group larger than 12 cm, Diptera *(Simulium* sp.) in the length group of 3-5.9 cm (39.21%) and 15-17.9 cm (27.61%). Ephemeroptera (*Epeorus alpicala*) formed a high percentage (45.76%) in brown trout larger than 21-23.9 cm.

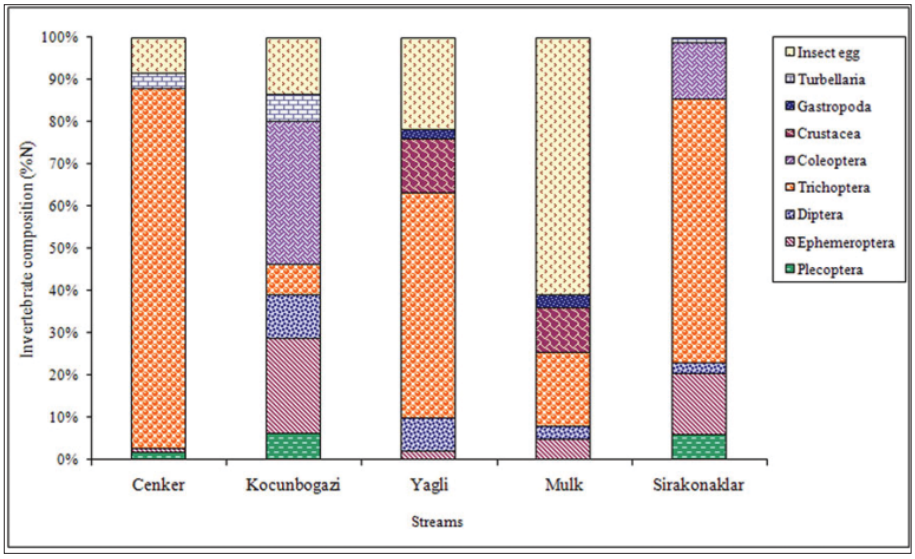

Fig 3. Relative abundance of inver-tebrates in studied streams in Çoruh River (N%)

Şekil 3. Çoruh Nehrinde çalışılan derelerdeki omurgasız canlıların nisbi bolluğu(%N)

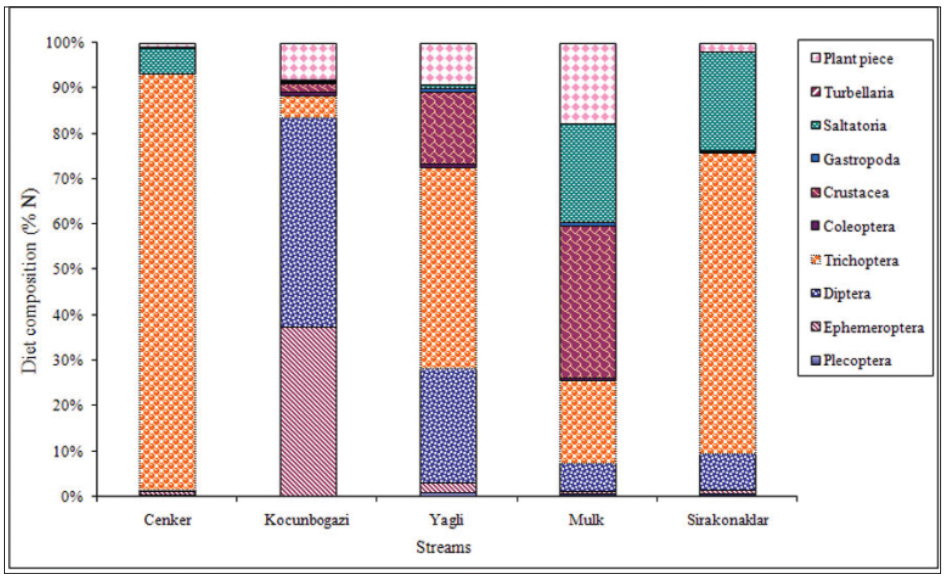

Fig 4. Composition of prey consumed by brown trout in studied streams in Çoruh River (%)

Şekil 4. Çoruh Nehrinde çalışılan derelerdeki alabalıklar tarafından tüketilen organizma kompozisyonu (%)

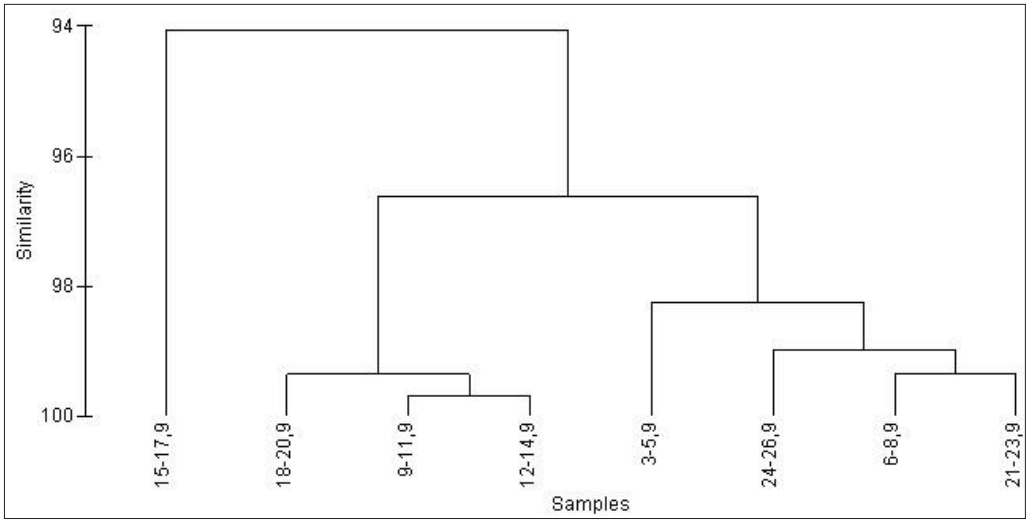

Fig 5. Cluster analysis of diets of brown trout in studied streams in Coruh River using Bray-Curtis similarity matrix

Şekil 5. Bray-Curtis benzerlik matriksi kullanarak Çoruh nehri üzerinde çalışılan derelerdeki alabalık besinlerinin cluster analizi

Food Niche Breadth of Brown Trout

The food niche breadth of brown trout was relatively wide; it averaged 1.24 in different size-classes and ranged from 0.75 to 1.84 for all size-classes, *(Fig. 5)*. Shannon's diversity index values are shown in *Table 2*.

The diet composition of brown trout in different length classes were further analyzed using cluster analysis. Minimum bray-curtis similarity among length-classes was over 94%. A minimum similarity group selection criterion was established. The most similar group was data from length-classes of 9-11.9 cm and 12-14.9 cm followed by length-classes 6-8.9 cm 21-23.9 cm.

DISCUSSION

Stomach contents of brown trout were extremely diverse. Our study showed that both aquatic invertebrates and terrestrial invertebrates were the main food for brown trout in the investigated streams, which is in good agreement with findings reported earlier in other studies [8]. There were variations in the relative importance of some other items among the streams. While the Trichopterans were the main food for brown trout in the Cenker, Sirakonaklar and Yagli streams, Ephemeropterans and Dipterans were the main food of brown trout in Kocunbogazi stream. In the Mulk and Sirakonaklar streams, Saltatoria *(Tetrix* sp.) are one of the dominant species in the macroinvertebrate community. Crustaceans *(Gammarus* sp.) were the main food for brown trout in Yagli and Mulk streams because of easlyn capture this invertebrate easily. Kara and Alp [20] mentioned that this crustaceans is the most important food source for brown trout in the upper sreams of Ceyhan and Euphrates river (Turkey). In river Nera, trichopteran larvae and ephemeropteran nymphs were the mean food sources for brown trout [21]. These slight differences were probably due to the prey availability and habitats among the streams [22].

Brown trout are visual predators and prefer active

Table 1. *Variations in the index of relative importance (IRI%) of major food items of brown trout in relation to length classes*
Tablo 1. *Boy sınıflarına göre alabalıkların temel besin maddelerinin nisbi önemlilik indeksindeki (%IRI)değişimler*

Organisms	Length-classes							
	3-5.9 cm	**6-8.9 cm**	**9-11.9**	**12-14.9**	**15-17.9**	**18-20.9**	**21-23.9**	**24-26.9**
Plecoptera	**0**	**0**	**0.8**	**0.044**	**0.007**	**0.131**	**0**	**0**
Perla sp.			0.79	0.044		0.073		
Protonemura sp.			0.01		0.007	0.058		
Ephemeroptera	**0**	**0**	**0.71**	**0.615**	**4.38**	**13.162**	**45.767**	**9.821**
Baetis sp.			0.55	0.529	1.179	2.408		
Ecdyonurus sp.				0.01	0.009	0.098		
Epeorus alpicala			0.16	0.076	3.192	10.656	45.767	9.821
Diptera	**39.21**	**0.86**	**0.93**	**2.22**	**28.132**	**6.193**	**0**	**25.978**
Dicranota sp.					0.248			
Simulium sp.	39.21		0.93	1.95	27.61	6.087		25.978
Liponeura sp.		0.86		0.27	0.274	0.077		
Tabanus sp.						0.029		
Trichoptera	**38.51**	**89.61**	**88.08**	**38.542**	**23.926**	**42.923**	**0.463**	**24.103**
Leptocerus sp.		0.73	13.83	16.592	3.216	1.161	0.201	
Sericostoma sp.		11.97	0.74	3.173	3.216	39.318	0.262	24.103
Hydrosyche sp.		0.42	0.74	1.697	5.958	2.262		
Rhyacophila sp.			0.02			0.182		
Limnephilus sp.	38.51	76.49	72.75	17.08	11.536			
Coleoptera	**0**	**0**	**0.04**	**0.008**	**0.077**	**0.063**	**0**	**0**
Helmis sp.			0.04	0.008	0.077	0.063		
Amphipoda	**0**	**0**	**0.02**	**0.44**	**1.102**	**4.869**	**0**	**0**
Gammarus sp.			0.02	0.44	1.102	4.869		
Gastropoda	**0**	**0**	**0.01**	**0**	**0.041**	**0.064**	**0**	**0**
Ancylus fluviatilis			0.01		0.041	0.064		
Saltatoria			7.95	57.088	28.991	23.504	53.323	28.803
Tetrix sp.			7.95	57.088	28.991	23.504	53.323	28.803
Turbelleria		**9.53**				**0.03**	**0.446**	
Planaria		9.53				0.03	0.446	
Other items	**22.27**		**1.47**	**1.043**	**7.47**	**9.064**		**11.295**
Plant piece	**22.27**		**1.47**	**1.043**	**7.47**	**9.064**		**11.295**

Table 2. *Species richness, diversity and number of species of brown trout in different length- classes from Coruh River*
Tablo 2. *Çoruh Nehrinde farklı boy sınıfındaki alabalıkların besinlerindeki tür sayısı, çeşitlilik ve tür zenginliği*

Length-classes	Number of Species	Diversity	Species Richness
3-5.9	3	0.43	1.07
6-8.9	6	1.09	0.78
9-11.9	10	1.95	0.96
12-14.9	10	1.95	1.29
15-17.9	12	2.42	1.84
18-20.9	10	1.95	1.72
21-23.9	5	0.87	0.75
24-26.9	5	0.87	1.53

benthic invertebrates (especially ephemeroptera [*Baetis* sp., *Ephemerella* sp.], diptera [Simuliidae] and water beetles [Dytiscidae and Elmidae]) that have high drift rates. Similar findings were mentioned in earlier studies [8]. Smaller prey items (i.e., chironomids) or those that camouflage or hide in the substratum (i.e., oligochaetes, molluscs and mayfly [*Ephemera* sp.]) are more difficult to detect, so a lower consumption of these items could be expected [22]. Fish of 3-11.9 cm and 12-20.9 cm were fed chiefly on Trichoptera *(Limnephilus* sp.), Saltatoria *(Tetrix* sp.) and Trichoptera *(Sericostomata* sp.), respectively. However, fish over 21 cm were fed primarily on Ephemeroptera *(Epeorus alpicala*), Diptera *(Simulium* sp.) and Saltatoria *(Tetrix* sp.).

In conclusion, this study shows that brown trout is

fed on a variety of prey items, and the diet and feeding behaviour changes related to habitat and fish size.

REFERENCES

1. Hunt PC, Jones JW: The food of broun trout in Ilyn Alaw. Anglesey. North Wales. *J Fish Biol,* 4, 333-352, 1972.

2. Hynes HBN: The ecology of running waters. *Annu Rev Entomol,* 15, 25-42, 1970.

3. Ware DM: Predation by rainbow trout: The influence of hunger, prey density and prey size. *J Fish Res Board Canada,* 29 (8): 1193-1201, 1972.

4. Wankowski JWJ, Thorpe JE: The role of food particle size in the growth of juvenile Atlantic salmon (*Salmo salar* L.). *J Fish Biol,* 14, 351-370, 1979.

5. Tippets WE, Moyle PB: Epibenthic feeding by rainbow trout in the McCloud River, California. *J Anim Ecol,* 47, 549-559, 1978.

6. Dahl J: Effects of a benthivorous and a drift feeding fish on a benthic stream assemblage. *Oecologia,* 116, 426-432, 1998.

7. Bridcut E, Giller PS: Movement and site fidelity in young brown trout *(Salmo trutta* L.) populations in a southern Irish stream. *J Fish Biol,* 43, 889-899, 1993

8. Kreivi P, Muotka T, Huusko A, Maki-Petays A Huhta A, Meisner K: Diet feeding periodicity, daily ration and prey selectivity in juvenile brown trout in a subarctic river. *J Fish Biol,* 55, 553-571, 1999.

9. Bridcut E, Giller PS: Diet variability in relation to season and habitat utilisation in brown trout, *Salmo trutta* L., in a southern Irish stream. *Canadian Special Publications Fisheries and Aquatic Sciences,* 118, 17-24, 1993.

10. Elliott JM: The food of trout *(Salmo trutta)* in a Dartmoor stream. *J Appl Ecol,* 4, 60-71, 1967.

11. Werner EE, Gilliam JF: The ontogenic niche and species interactions in size-structured populations. *Ann Rev Ecol Syst,* 15, 1042-1052, 1984.

12. Keeley Er, Grant JWA: Allometry of diet selectivity in juvenile Atlantic salmon *(Salmo salar*). *Can J Fish Aquat Sci,* 54, 1894-1902, 1997.

13. Zippin C: The removal method of population estimation. *J Wildlife Mgmt,* 22, 82-90, 1958.

14. Demirsoy A: Yaşamın Temel Kuralları. Cilt 2, Kısım 2: Omurgalılar/ Böcekler Entomoloji. s. 941, Hacettepe Üniversitesi Yayınları, 1990.

15. Quigley M: Invertebrates of Streams and Rivers: A Key to Identification. Hodder Arnold H&S, 1977, P. 63, ISBN: 07131 00915, 1980.

16. Bowen SH: Ouantitive description of the diet. **In,** Murphy BR, Willis DW (Eds): Fish Techniques. 2nd ed., pp. 213-232, American Fish Soc Bethesda, Maryland, 1996.

17. Pinkas L, Oliphant, MS, Iverson LK: Food habits of albacore, bluefin tuna, and bonito in California waters. California Dep., Fish Game, *Fish Bull,* 152, 105, 1971.

18. Marshall S, Elliott M: A comparison of univariate and multivariate numerical and graphical techniques for determining inter- and intra-specific feeding relationships in estuarine fish. *J Fish Biol,* 51, 526-545, 1997.

19. Shannon CE, Weaver W: The Mathematical Theory of Communication. Urbana: University of Illinois Press, 1949.

20. Kara C, Alp A: Feeding habits and diet composition of brown trout *(Salmo trutta)* in the upper streams of River Ceyhan and River Euphrates in Turkey. *Turk J Vet Anim Sci,* 29, 417-428, 2005.

21. Fochetti R, Argano R, Figueroa JMT: Feeding ecol of various age-classes of brown trout in River Nera, Central Italy. *Belg J Zool,* 138 (2): 128-131, 2008.

22. Oscoz J, Leunda PM, Campos F, Escala MC, Garcia-Fresca C, Miranda R: Diet of 0+ brown trout *(Salmo trutta* L., 1758) from the Erro River (Navarra, North of Spain). *Limnetica,* 24 (3-4): 319-326, 2005.