Acta Biologica Turcica 30 (1) 1-6, 2017 Received 10 Oct. 2016; Accepted 12 Jan. 2017

ACTA BIOLOGICA TURCICA

E-ISSN: 2458-7893, http://www.actabiologicaturcica.info

Age, growth, sex ratio and feeding of *Knipowitschia caucasica* (Berg, 1916) (Actinopterygii, Gobiidae) in non-native species of Eğirdir Lake (Turkey)

Salim Serkan GÜÇLÜ[1,*], Ömer ERDOĞAN[2]

[1]Eğirdir Fisheries Faculty, Süleyman Demirel University, Isparta, Turkey.
[2]Yalvaç Technical Sciences Vocational School, Environmental Protection Department, Süleyman Demirel University, Yalvaç-Isparta, Turkey.
*Corresponding author: salimguclu@sdu.edu.tr

Abstract: The population structure of *Knipowitschia caucasica* (Caucasian dwarf goby) in Lake Eğirdir (Turkey) was studied, using 400 fish monthly in 2008. Males made up 45.75% (183), females 50.50% (202) and juveniles 3.75% (15) of the population. The length-weight relationship and Von Bertalanffy growth equation were estimated as $W=0.0141*L^{2.769}$ (r=0.7464), $W=0.0116*L^{2.941}$ (r=0.8266) and $W=0.0129*L^{2.8494}$ (r=0.8039) for females, males and combined sexes, respectively. This species can be mainly fed with Ochrophyta, *Gammarus pulex* and Ostracoda organisms. There is a food competition among *Atherina boyeri*, *Aphanius anatoliae* and *K. caucasica* that live mainly in coastal areas and share the same environment. The species has become one of the dominant fish of lake along with *Carassius gibelio* (non-native), *A. anatoliae* (native) vs *A. boyeri* (non-native).

Keywords: Anatolia, Exotic species, Competition, Population features.

Introduction

Knipowitschia, a "sand-goby" genus of Ponto-Caspian origin is comprised of fifteen described eurytopic or freshwater species, mostly endemic with limited distribution in the habit of the Black and Caspian Sea, and drainages of the Aegean, Ionian, Adriatic Sea and Anatolia (Miller, 2004; Kovačić, 2005). There are approximately 15 species in this genus (Ahnelt, 1995; Miller, 2004; Kovačić, 2005; IUCN, 2013). The well-known *Knipowitchia* members in Turkey are *K. caucasica*, *K. ephesi* (endemic), *K. longecaudata*, *K. mermere* (endemic), *K. caunosi* (endemic) and *K. byblisia* (endemic) (Ahnelt, 1995, 2011; Neer et al., 1999; Turan et al., 2005).

Knipowitschia caucasica is found in Eğirdir, Eber, Sapanca, Beyşehir and Büyükçekmece lakes; Great Meander (lakes Bafa, Çivril and Demirköprü) and Evros river basin (Neer et al., 1999; Balık et al., 2005; Tarkan et al., 2006; Yeğen et al., 2006; Özuluğ et al., 2007).

It was first recorded in Çayköy Canal as *Pomatoschistus marmoratus* by Küçük (1998); however, Neer et al. (1999) redefined it as *K. caucasica*. Although there is insufficient information concerning its origin, *K. caucasica* is thought to be an alien species for the lake. As no record was given in previous studies carried out by various researchers (Pietschmann, 1933; Kosswig and Geldiay, 1952; Sarıhan, 1970; Campell, 1992; Ekmekci and Erk'akan, 1997), and that has not found in pike-perch stomachs, this theory is thought to be valid. The lack of information on this subject was reported Neer et al. (1999) and it was documented that this species may have inadvertently entered in the lake while stocking with other fish species.

In the present study, information on the population structure, food and feeding of *K. caucasica* in the Lake Eğirdir, its relationship with other fish species and the status in the lake are presented.

Materials and Methods

Lake Eğirdir was formed as a result of a subsidence located in the intersection area of the Menderes-Taurus and East Taurus blocks of the Central Anatolian Plateau. The first signs of the formation of this lake can be traced to the Upper Cretaceous (Mesozoic-Tertiary, 65 million

Table 1. Age and sex distribution of *Knipowitschia caucasica* from the Lake Eğirdir (N: Number of samples, N%: Percent of samples, Females (F), Males (M)).

Age group	Females		Males		Immature		All		M:F
	N	N%	N	N%	N	N%	N	N%	
0	70	17.50	66	16.50	10	2.50	146	36.50	**0.94:1.**
I	127	31.75	106	26.50	5	1.25	238	59.50	**0.83:1.**
II	5	1.25	7	1.75	-	-	12	3.00	**1.40:1.**
III	-	-	4	1.00	-	-	4	1.00	**4.00:1.**
Total	202	50.50	183	45.75	15	3.75	400	100	**0.90:1.**

years ago) period, and the current sediment remains hold traces of the Plio-Quaternary period (2 Mya-10 Kya) (Görmüş et al., 2005). Therefore, the central Anatolian Plateau has a high rate of endemism.

Lake Eğirdir is located at latitude 38°15′N and longitude 30°52′E in the Lake District (southwest Turkey) and second largest freshwater lake of Turkey (918 m sea level, 8-9 m mean depth.)

Today, there are 15 fish taxa (10 native, 5 non-native) present in Lake Eğirdir. It was determined that, among the endemic species of Lake Eğirdir, Handlirsch's minnow (*Pseudophoxinus handlirschi*) is extinct (EX), Ereğli minnow (*Hemigrammocapoeta kemali*) disappeared and Eğirdir minnow (*P. egridiri*) and Eğirdir barb (*Capoeta pestai*) are critically endangered (CR) (Küçük et al., 2009).

The first major change to the natural fish fauna in Lake Eğirdir began in 1955 with the intentional introduction of *Sander lucioperca*, an alien piscivorous fish. Then, omnivorous fish *Carassius gibelio* in 1996 and planktivorous-carnivorous *Atherina boyeri* in 2003 were introduced to lake through unknown methods. The native fish fauna changed greatly due to alien fish introductions and overfishing. The major fish species in the lake are the silver crucian carp (*Carassius gibelio*), Anatolian killifish (*Aphanius anatoliae*), Caucasian dwarf goby (*K. caucasica*) and big-scale sand smelt (*A. boyeri*).

Monthly samples were collected from the Lake Eğirdir between April 2007 and March 2008 with drift nets of tulle of 2 mm mesh size. In this study, a total of 400 specimens were examined. The total lengths of all fish measured with 0.01 mm sensitive calipers, whereas weights were recorded with an electronic balance at the nearest 0.01 g. The age was determined from scales. The overall ratio of males to females was evaluated with χ^2 test (0.05) (Düzgüneş et al., 1995). The relation of weight to total length was established by the exponential regression equation, $W=a*TL^b$, where W is the weight in g, TL the total length in cm, a and b the parameters to be established (Ricker, 1975). The growth of the *K. caucasica* population was estimated with the following Von Bertalanffy growth equations:

$$L_t=L_\infty(1-e^{-k(t-to)}),$$

Where L_t is the total length in cm at age "t", L_∞ the average asymptotic length in mm, k the body growth coefficient, "to" the hypothetical age and "a" and "b" constants (Kara, 1992). Food selection was expressed as the percent distribution of the monthly consumed food types. Food organisms founded in the alimentary canal were identified using various textbooks (Smith, 2001).

Results

The age structure of the sampled fish ranged from 0 to III years (Table 1). Of the total fish examined, 183 (45.75%) were males, 202 (50.50%) females and 15 (3.75%) immature. The overall ratio of males to females was 0.90:1.00 and χ^2 analysis showed this sex ratio to be not significant ($P>0.05$) (Table 1). The fish size and age classes are indicated in Table 2.

The following Von Bertalaffy growth equation was obtained as $L_t=232.65(1-e^{-0.026(t+5.115)})$ for sexes combined. The differences between observed and expected total lengths were statistically not significant in all age groups (t-test, $P>0.05$). The total length-weight relationships were calculated for all *K. caucasica* samples. The length-weight relationships are represented in Figure 1.

The monthly stomach contents are presented as the percent distribution of organisms identified from the alimentary canal (Table 3). Ostracoda, Amphipoda

Table 2. Size and age composition of females (F), males (M) and immature (I) of *Knipowitschia caucasica* from the Lake Eğirdir (total length (TL) in mm).

Total Length (mm)	Age Class												Total
	0			I			II			III			
	F	M	I	F	M	I	F	M	I	F	M	I	
22.96-25.36	2	1	3										6
25.37-27.77	14	13	4										31
27.78-30.18	47	42	3										92
30.19-32.59	7	10		56	35	2							110
32.60-35.00				54	37	2							93
35.01-37.41				16	33	1							50
37.42-39.82				1	1		4	4					10
39.83-42.23							1	3					4
42.24-44.64											3		3
44.65-47.05											1		1
∑	**70**	**66**	**10**	**127**	**106**	**5**	**5**	**7**	**0**	**0**	**4**	**0**	**400**

Table 3. The monthly percent distribution of organisms in the alimentary canal of *Knipowitschia caucasica* from the Lake Eğirdir (%).

	A	M	J	J	A	S	O	N	D	J	F	M	∑
Ochrophyta	72.82	82.60	87.87	59.48	47.20	43.00	-	42.00	-	-	14.00	-	**37.51**
Veliger larvae	-	-	-	-	-	2.00	-	8.00	9.00	17.00	26.00	25.00	**7.26**
Rotifera	-	-	-	2.40	5.60	-	-	-	-	-	-	-	**0.68**
***Alona* sp.**	0.97	-	-	2.40	8.30	-	-	2.00	-	-	-	-	**1.14**
Ostracoda	-	-	-	-	-	-	33.00	37.00	55.00	66.00	18.00	25.00	**19.50**
Gammarus pulex	20.39	13.52	5.30	19.04	25.00	53.00	67.00	6.00	27.00	17.00	32.00	37.00	**26.90**
Asellus aquaticus	1.94	1.94	-	-	-	-	-	-	-	-	-	-	**0.33**
Ephemeroptera imago	1.94	-	-	-	-	-	-	2.00	-	-	-	-	**0.34**
Trichoptera imago	-	-	6.83	9.49	8.30	-	-	3.00	-	-	-	-	**2.30**
Trichoptera larvae	0.97	0.97	-	2.40	-	-	-	-	-	-	5.00	13.00	**1.87**
Diptera larvae	0.97	0.97	-	-	-	-	-	-	-	-	-	-	**0.17**
Empty stomach	-	-	-	2.40	5.60	2.00	-	-	9.00	-	5.00	-	**2.00**

(*Gammarus pulex*) and Ochrophyta are the major food resources for *K. caucasica*. *Knipowitschia caucasica* prefers to feed on zooplankton in winter and spring while choosing benthic feeding in summer and autumn.

Discussion

In this study, the age of *K. caucasica* from the Lake Eğirdir ranged from 0 to III. Nikolsky (1980) suggested that the situation in wide range of age distribution in a population are to accepted as a indication of enough level in the food of water system. The decrease of individual in old age groups in the population will cause increase of individual in young age groups, decreasing the food competition.

The sex ratio of females to males of *K. caucasica* of the Lake Eğirdir is 0.90:1.00 (χ^2, P>0.05). This ratio found in the research is similar to ratio 1.00:1.00 give for a number of species (Nikolsky, 1980). According to Nikolsky (1980), sex ratio varies considerably from species to species, but in the majority of species it is close to one. The sex ratio of females to males is similar to population of Evros Delta (Kevrekidis et al., 1990).

The correlation coefficient of length-weight relationship in *K. caucasica* was calculated r=0.8049 for

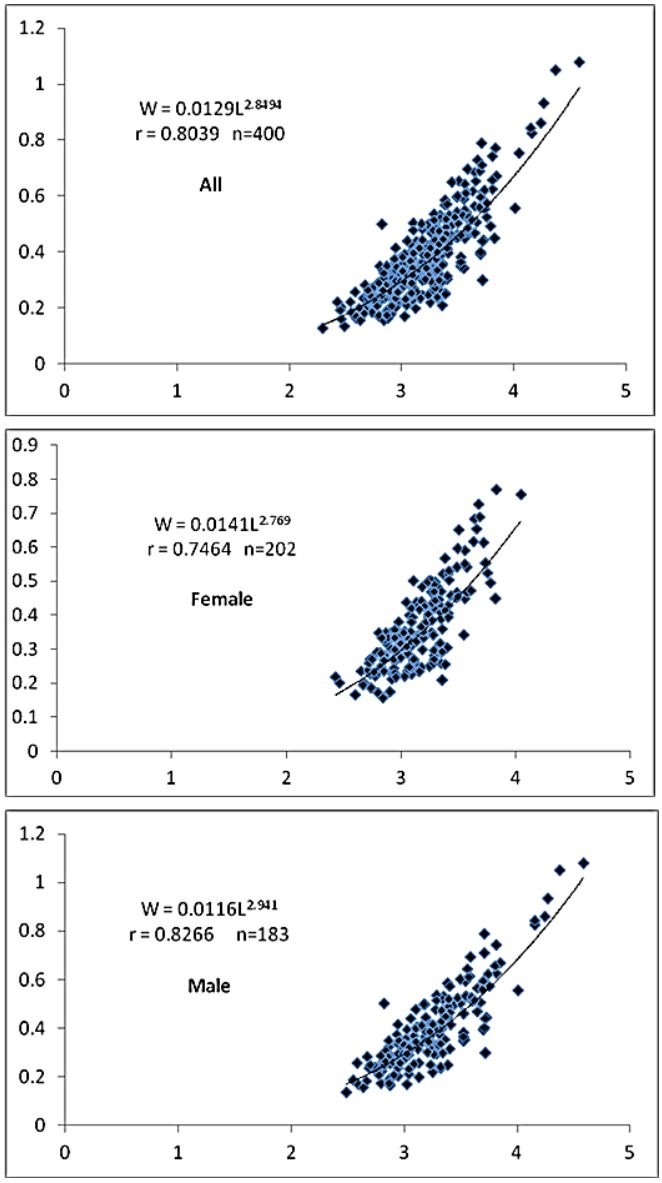

Figure 1. The total length-weight relationships of *Knipowitschia caucasica* from the Lake Eğirdir (All, Female and Male).

combined sexes. This is unimportant from the expected increase in length-weight relationship. In this study relationship is similar to *K. caucasica* (Tarkan et al., 2006; Kevrekidis et al., 1990).

Fifteen different groups of organisms have been encountered in digestive tract of individuals of Lake Eğirdir and it was determined that densely consumed Ostracoda, Bivalves larvae (*Dreissena polymorha*) and Amphipoda (*Gammarus pulex*). Species do not have the trouble finding food in their surroundings and they mostly preferred benthic feeding regime all year. At a result of exhibits that the population of *K. caucasica* is a developing population. Feeding of individuals in the Evros Delta (Greece) (Kevrekidis et al., 1990) shows a limited varies containing only six food categories. The most densely food organisms was *Ficopomatus enigmaticus, Hediste diversicolor* and *Gammarus aequicauda.* According to the study, it was determined that *K. caucasica* fed from the ground and preferred to benthic life. Population of Trichonis Lake (Greece) (Economou et al., 1994) fed 10 different groups of organisms. Copepoda and *Dreissena polymorpha* larvae were densely found within food organisms. According to these data, it was concluded that *K. caucasica* fed from the ground. Cambell (1992) and Ekmekçi and Erk'akan (1997) have not found *K. caucasica* in nutrient content of pike-perch in Lake Eğirdir. On the contrary, Balık et al. (2006) determined that the primary food of pike-perch (*S. lucioperca*). These results confirmed the arrival date of the species in the Lake Eğirdir (Neer et al., 1999). In the 2 year-long study related to feeding of population of *A. boyeri*, *K. caucasica* was not found in the digestive tract of fish (Küçük et al., 2006). It have shown there is no feeding relationship between two non-native species of lake. *Atherina boyeri* which sharing the same habitat of lake and being other foreign fish consumed 22 different food organisms and it shared 10 of these organisms with *K. caucasica* (Küçük et al., 2006). Connected with excessive growing of sand smelt, for fishing seasons, It could be captured only goldfish (*C. gibelio)*, when pike-perch (*S. lucioperca*) and carp (*Cyprinus carpio*) density in the lake was decreased until limited level. *Knipowitschia caucasic*a and *A. anatoliae* population, which got free from fishing pressure, was massively increased. In another study made in same period (Güçlü, 2012), *A. anatoliae,* the other fish sharing the same habitat and also the lake's native fish, consumed 16 different food organisms, sharing 11 of these organisms with *K. caucasica.* There is a food competition between *A. boyeri*, *A. anatoliae* and *K. caucasica* that especially living in the coastal areas and sharing the same environment. However, this does not seem to affect the development of three populations.

In conclusion, *K. caucasica* have quite adapted to the environment and has created a devoloping population. The species has become one of the dominant fish of the lake together with *C. gibelio* (non-native), *A. anatoliae* (native) and *A. boyeri* (non-native).

Acknowledgements

I would like to thanks, Z. Güçlü for great help in the field

and laboratory.

References

Ahnelt H. 1995. Two new species of *Knipowitschia* Iljin, 1927 (Teleostei: Gobiidae) from Western Anatolia. Mitteilungen aus dem Hamburgischen Zoologischen Museum und Institut, 92: 155-168.

Ahnelt H. 2011. Two new sympatric *Knipowitschia* species (Teleostei: Gobiidae) from an eastern Mediterranean coastal lake-examples of different dispersal patterns? Zootaxa, 3114: 22-30.

Balık S., Ustaoğlu M.R., Sarı H.M., İlhan A., Topkara E.T. 2005. The fish fauna of Yuvarlakçay (Köyceğiz, Muğla). Ege University Journal of Fisheries and Aquatic Sciences, 22 (1-2): 221-223. (In Turkish with English abstract)

Balık İ., Çubuk H., Özkök R., Uysal R. 2006. Fish fauna and fisheries in Lake Eğirdir: Changes from 1950s, when Pikeperch (*Sander lucioperca* (Linnaeus, 1758)) was introduced to today. 1. Balıklandırma ve Rezervuar Yönetimi Sempozyumu, 105-118, Antalya (In Turkish with English abstract).

Campbell R.N.B. 1992. Food of an introduced population of pikeperch, *Stizostedion lucioperca L.* in Lake Egirdir, Turkey. Aquaculture and Fisheries Management, 23: 71-85.

Düzgüneş O., Kesici T., Gürbüz F. 1995. İstatistiki Metodlar. Ankara Üniversitesi Ziraat Fakültesi Yayınları, No: 1291, Ankara. 218 p. (In Turkish)

Ekmekçi G., Erk'akan F. 1997. Evaluation of changes in Pikeperch *Stizostedion lucioperca* (L. 1758) population in Eğirdir Lake. Turkish Journal of Zoology, 21: 421-430.

Economou A.N., Daoulas C., Psarras T., Barbihri-Tseliki R. 1994. Further data on the reproduction and larval development of *Knipowitschia caucasica* (Gobiidae). Journal of Fish Biology, 45(2): 360-362.

Görmüş M., Çoban H., Caran Ş., Uysal K., Bircan H., Tunç İ.O. 2005. Eğirdir Gölü Batısı Pliyo-Kuvaterner Sedimanları. Türkiye Kuvaterner Semp., İTÜ Avrasya Yer Bilimleri Enst. 205-218. (In Turkish)

Güçlü S.S. 2012. Population structure of Killifish, *Aphanius anatoliae* (Cyprinodontidae) endemic to Anatolia in Lake Eğirdir-Isparta (Turkey), Iranian Journal of Fisheries Sciences, 11(4): 786-795.

IUCN. 2013. IUCN Red List of Threatened Species. Available online at www.iucnredlist.org. Accessed in 25.11.2013.

Kara F. 1992. Balıkçılık Biyolojisi ve Populasyon Dinamiği. Ege Üniversitesi Su Ürünleri Yüksekokulu Kitapları Serisi, No: 27, Ege Üniversitesi Basımevi, İzmir. 168 p. (In Turkish)

Kevrekidis T., Kokkinakis A.K., Koukouras A. 1990. Some aspects of the biology and ecology of *Knipowitschia caucasica* (Teleostei: Gobiidae) in the Evros Delta (North Aegean Sea). Helgolander Meeresuntersuchungen, 44 (2): 173-187.

Kosswig C., Geldiay R. 1952. Eğirdir Gölü balıkları. Balık ve Balıkçılık, İst Üniv. Fen Fak. Hidrobiyoloji Arş. Enst. Yayınları, 3-1: 3-14.

Kovačić M. 2005. A new species of *Knipowitschia* (Gobiidae) from Dalmatia, Croatia. Cybium, 29(3): 275-280.

Küçük F. 1998. Isparta İli İçsularında Yayılış Gösteren Tatlısu Balıklarının Sistematik ve Ekolojik Özellikleri Üzerine Araştırmalar. SDÜ. Isparta'nın Dünü, Bugünü, Yarını Sempozyumu, 2 (2): 75-88. (In Turkish)

Küçük F., Gülle İ., Güçlü S.S., Gümüş E., Demir O. 2006. Effect on fishery and lake ecosystem of non-native sand smelt (*Atherina boyeri* RISSO, 1810) in Eğirdir Lake. 1. Balıklandırma ve Rezervuar Yönetimi Sempozyumu, p: 119-128, Antalya. (In Turkish with English abstract)

Küçük F., Sarı H.M., Demir D., Gülle İ. 2009. Review of the ichthyofaunal changes in Lake Eğirdir between 1915 and 2007. Turkish Journal of Zoology, 33: 277-286.

Miller P.J. 2004. *Knipowitschia* Iljin, 1927. In: P.J. Miller, (ed.): The Freshwater Fishes of Europe. Vol. 8: Gobiidae. Wiesbaden: AULA-Verlag. pp: 331-337.

Nikolsky G. 1980. Theory of fish population dynamics as the biological background for rational exploitation and management of fishery resources. Otto Koeltz Science Publishers, Koenigstein.

Özuluğ M., Tarkan A.S., Gaygusuz Ö., Gürsoy Ç. 2007. Two new records for the fish fauna of Lake Sapanca Basin (Sakarya, Turkey). Journal of Fisheries Sciences, 1(3): 152-159.

Pietschmann, V. 1933. Drei neue Fisharten aus Kleinasien. Mat. nat. KI. Wien, 70: 21-23.

Ricker W.E. 1975. Computation and interpretation of biological statistics of fish populations. Journal of the Fisheries Research Board of Canada, No: 191. 382 p.

Sarıhan E. 1970. On the biological and economic changes occurred in the Lake Eğirdir after the transplantation of pikeperch (*Lucioperca lucioperca*). İstanbul University Publications of the Hydobiological Research Ins. B, VI-3: 3-4.

Smith D.G. 2001. Pennak's freshwater invertebrates of the United States (Porifera to Crustacea). Fourth Edition. John Wiley and Sons Inc. 638 p.

Tarkan A.S., Gaygusuz Ö., Acıpınar H., Gürsoy Ç., Özuluğ M. 2006. Length-weight relationship of fishes from the Marmara region (NW-Turkey). Journal of Applied Ichthyology, 22: 271-273.

Turan D., Berber S., Topkara E.S., Verep B. 2005. A First record (*Knipowitschia longicaudata* (Kessler, 1877)) for the fish fauna of Lake Manyas. Turkish Journal of Zoology, 29: 171-176

Neer V.W., Wildekamp R.H., Kucuk F., Ünlüsayın M. 1999. First inland records of the euryhaline goby *Knipowitschia caucasica* from lakes in Anatolia, Turkey. Journal of Fish Biology, 54: 1334-1337.

Yeğen V., Balık S., Bostan H., Uysal R., Bilçen E. 2006. Recent Status of Fish Faunas in Some Lakes and Dams in Lakes Region. 1. Balıklandırma ve Rezervuar Yönetimi Sempozyumu, Antalya. pp: 129-140. (In Turkish with English abstract)