The Growth and Reproduction Characteristics of *Neogobius melanostomus* Populations in its Native Habitat of Lake Karaboğaz (Black Sea, Turkey)

Neogobius melanostomus'un Yerel Habitatı Olan Karaboğaz Gölü'nde (Karadeniz, Türkiye) Yaşayan Populasyonunun Büyüme ve Üreme Özellikleri

Research Article

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ABSTRACT

The age and size composition, growth rate and reproductive biology of the round goby, *Neogobius melanostomus,* were studied from 266 specimens from August 2011 to August 2012. The ages of *N. melanostomus* ranged from I to IV years, with age class II years dominant. The female: male ratio of the sample was found to be 0.62:1. The results indicated that the total value of the whole population size varied from 91 mm to 190 mm and the weight value varied from 12 g to 119 g. The minimum and maximum total length for female and male were 100-166 mm and 91-190 mm, respectively. According to these results, it was determined that the growth values of *N. melanostomus* living in Lake Karaboğaz are significantly higher than Great Laurentian Lakes Basin, and lower than Baltic Sea populations. The sexual maturation age of *N. melanostomus* was year I for female and year II for male and the reproduction period of this species was in April - September. The highest number of eggs of *N. melanostomus* population living in Lake Karaboğaz was 2477 but it was determined to be lower than the expected values.

Key Words

Neogobius melanostomus, invasive species, growth, reproduction.

ÖZ

Neogobius melanostomus'un yaş ve boy ilişkileri, büyüme özellikleri ve üreme özelliklerinin araştırıldığı bu çalışma 266 türde, Ağustos 2011-Ağustos 2012 tarihleri arasında gerçekleştirilmiştir. Yapılan araştırma sonucunda yaş dağılımı I-IV arasında olmakla birlikte, baskın yaş sınıfı II'dir. Dişi:erkek oranı 0.62:1 olarak tespit edilmiştir. Tüm populasyonda toplam boy değerleri 91-190 mm arasında değişirken, ağırlık değerleri 12-119 g arasında değişmektedir. Toplam boy minimum ve maksimum değerleri dişilerde 100-166 mm, erkeklerde ise 91-190 mm arasındadır. Bu sonuçlara göre Karaboğaz Gölü'nde yaşayan *N. melanostomus*'un büyüme değerleri Great Laurentian Gölleri'nde sistemlerde yaşayan populasyonlardan daha yüksek, Baltık Denizi populasyonlarından ise daha düşüktür. *N. melanostomus*'un eşeysel olgunluk yaşı dişilerde I, erkeklerde ise II olarak tespit edilmiştir. Ayrıca türün üreme dönemi nisan ve eylül ayları arasındadır. Karaboğaz Gölü'nde yaşayan *N. melanostomus* populasyonunun en yüksek yumurta sayısı 2477 olmakla birlikte beklenen değerlere göre düşük sayıda olduğu tespit edilmiştir.

Anahtar Kelimeler

Neogobius melanostomus, istilacı türler, büyüme, üreme.

INTRODUCTION

N. melanostomus (Pallas, 1814) is a member of the Gobiidae family and a bottom-dwelling fish native to the Ponto-Caspian region [1]. *N. melanostomus* also occur in lower and middle reaches of rivers, but only in slightly brackish or freshwater [2]. During spring through fall in the Black Sea, round gobies are found in slow rivers, lagoons and brackish coastal water up to 20m, and migrate to inshore areas of the North Caspian region even while these areas are still partially frozen [3].

Ship ballast-water transport is considered to be the most probable human-mediated means by which the fish have been transferred and introduced to new locations [4]. The round goby has successfully invaded several European and North American water bodies including the Baltic Sea [5-9], Germany [10,11], Chicago [12,13], Canada [14], Atlantic [15], the Netherlands [16], Hungary [17], Russia [18], Lithuania [19]. Although *N. melanostomus* is a native species in the aquatic ecosystems of Turkey, its occurrence threatens other aquatic ecosystems. Having an important role in the invasion, many studies have been conducted and conferences and meetings have been organized about round goby [20]. Understanding life-history characteristics, such as growth, is vital for predicting the long-term effects of non-native species and developing practical management [21] along with long-term conservation techniques [22]. Despite several studies on the biology, ecology and natural history of *N. melanostomus*, there have not been any studies directly examining the growth and reproductive characteristics of the individual fish from the native habitat for the purpose of examining their natural history. Tarkan et al. (2006) investigated the length-weight relationships of *N. melanostomus* in the Sea of Marmara and Demirhan and Can (2007) studied them in the Black Sea [23,24]. Although these studies reported the length-weight relationships of the round goby, they were not able to give information on the seasonal growth and reproductivity of *N. melanostomus*. The present study aimed to determine the growth rate and breeding season of *N. melanostomus* in the native habitat (Figure 1).

MATERIALS and METHODS

Study Site

The Kızılırmak Delta is one of the biggest and most important wetlands located on the Black Sea coasts of Turkey. The whole delta is one of 13 Ramsar sites in Turkey. The Delta has been shown among the most important Bird Areas (IBA) of

Figure 1. Lake Karaboğaz, the lagoon lake where the study was conducted, Turkey.

Europe by BirdLife International. Lake Karaboğaz (north latitude 41º38' and east longitude 35º38'), where the study was conducted, is a brackish water lagoon lake located 10 km west of the mouth of the Kızılırmak at sea level with the surface area of 1500 hectares. Lake Karaboğaz is the closest lake to the sea in the Kızılırmak Delta and connects to the Black Sea via a narrow sandy barrier located in its north-west region (Figure 1). The length of the lake is 6 km and the width is approximately 1 km. Lake Karaboğaz is shallow like other lagoons in the delta and its deepest area is approximately 2.5 meters. It is characterized by brackish water due to the salt water entering from the north. The freshwater inflow is provided by small streams from the south to the lake (the Marda and Berdaş Streams).

In the monthly measurements made in Lake Karaboğaz between August 2011 and August 2012, the depth of the lake water was determined to be between 40-240 cm. The water temperature varies between 6.1-26.7ºC depending on the season. The dissolved oxygen values of the lake, of which light transmittance is between 25-160 cm, vary between 2.4-13.9 mg/l. The salinity of Lake Karaboğaz, which is a lagoon lake, varies between 0.5-20.9. According to the data obtained, Lake Karaboğaz is in the mixo-oligohaline class in general.

Sampling Methods
The monthly sampling was performed in Lake Karaboğaz between August 2011 and August 2012 at 4 stations. The sampling could not be performed in January 2012 due to the unfavourable weather conditions. In the determination of the stations, the connection of the lake to the sea (1st station), the channels (2nd and 3rd station) providing the freshwater inflow to the lake from residential areas and agricultural lands, and the mirror of the lake (4th station) were taken into consideration. The physical characteristics of the lake water such as the water temperature, depth, light transmittance, dissolved oxygen, electrical conductivity, salinity and pH were measured from the determined stations using YSI 556 MPS, Hydrobios Secchi Disc at the site.

Simple trammel nets with 17 mm mesh opening were used for fishing. The fish samples caught were placed in jars containing 4% formaldehyde and brought to the laboratory. While the study of Lagler (1966) was used in the scale preparations prepared for the age determination, the studies of Cragg-Hine and Jones (1969), Philipart (1972) and Thomas (1968) were used in the identification of age rings [25-28]. All individuals within the scope of the study were classified by age groups and sex. The sex of the samples was determined macroscopically by looking at the urogenital papilla in the ventral of individuals and by performing dissection [2].

Data analysis
All individuals caught during the study were classified by age and sex groups, and the Specific growth rate was calculated according to Wootton (1990): $G_L = (\log_e L_{Tf}.L_{Ti}^{-1})t^{-1}$ and $G_w = (\log_e w_f.W_i^{-1})t^{-1}$, where G_L is the length growth rate, G_w is the weight growth rate, L_{Tf} is the final L_T and L_w is the final W, L_{Ti} and W_i are the initial L_T and W and t is the time interval [29]. Fulton's condition factor (K) was calculated monthly as $K = 10^5/L_t^3$, $K = W 10^5/L_t^3$. The von Bertalanffy growth equation was estimated by $L_t = L_\infty[1-e^{-k(t-t0)}]$. The growth performance index was estimated by $\emptyset = \log_{10}(k) + 2\log_{10}(L_\infty)$ [29].

The gonads of female and male individuals were weighed at 0.01 mg sensitivity for the determination of their reproduction period and calculation of the gonadosomatic index. The number of eggs was estimated by the Gravimetric Method using ovaries preserved in 4% formaldehyde. Furthermore, fecundity was calculated by using the Gravimetric Method [31]. In female individuals, the egg diameter was measured in 30 eggs taken from the head, middle and end part of the gonads. The fish egg diameters were calculated by taking the mean of the obtained values. The change of the gonadosomatic index (GSI) and egg diameter by months was taken as a basis for determining the reproduction period. The gonadosomatic index was calculated with the equation of GSI = (G_w/W) x 100 [32].

RESULTS

Age and Growth
The age range of 266 samples obtained from Lake Karaboğaz was found to be between I and IV in both male and female individuals. The total length and weight values by sex are presented in Table 1.

Table 1. Total length and weight values in the male and female individuals of *Neogobius melanostomus* obtained from Lake Karaboğaz.

Age	Male Total length mean±SE (min-max)	Female Total length mean±SE (min-max)	p value	Male Total weight mean± SE (min-max)		Female Total weight mean±SE (min-max)	p value
I	117.9±3.2 (91-136)	105.2±1.0 (100-110)	0.003	30.5±2.4	(12-37)	26.2±2.8 (13-38)	0.258
II	135.2±1.1 (115-175)	124.0±1.2 (111-143)	0.000	40.9±1.3	(17-48)	32.5±0.9 (19-81)	0.000
III	147.4±2.0 (122-190)	133.5±1.7 (120-161)	0.000	56.5±2.4	(28-70)	39.2±1.4 (32-105)	0.000
IV	158.8±3.9 (134-184)	142.5±3.5 (135-166)	0.008	73.2±6.4	(38-82)	48.8±4.1 (33-119)	0.011

While the total length varied between 91-190 mm, the weight varied between 12-119 g. The mean total length and weight values of males were found to be higher compared to females for all age groups. According to the results of the ANOVA test conducted, a statistical difference was also found between the total lengths and weights of male and female individuals in all age groups.

The von Bertalanffy equation is $L_t = 15.44[1-e^{-0.47(t+5.98)}]$ in female individuals and $L_t = 19.96[1-e^{-0.23(t+4.82)}]$ in male individuals. The L_∞ values are higher in male individuals (19.96) than female individuals (15.44). The growth performance index value, Ø, was calculated to be 2.045 in female individuals and 1.964 in male individuals.

The specific growth rate values slightly differ between female and male individuals. The GL values were found to be high in both male and female individuals in the transition from age 1 to age 2, which is the first year of growth. However, the GW values were different between sexes but significant differences were not determined between the ages (Table 2).

Although the condition factor varies by months in both female and male individuals, increases and decreases correspond almost to the same months (Figure 2).

Reproduction

All samples were separated according to sex, and 102 females and 164 males were identified. While the F: M ratio was 0.62:1 in all individuals, the sex ratio by ages was different from the ideal sex ratio (1:1). The dominant age group was 2 and 3 (Table 3).

While the mean GSI values were higher in female individuals (8.25) than male individuals (1.12), the GSI changed in similar months in both male and female individuals. The highest GSI value was determined in April in female individuals (15.0) and in May in male individuals (3.3). The lowest GSI values were determined in female and male individuals in November (0.45) and September (0.07), respectively (Figure 3).

In all female individuals obtained from the study (102), the egg diameter was calculated and the change by months was determined. While the highest egg diameter was determined in May, the lowest value was determined in November (Figure

Table 2. GL and GW values of the male and female individuals of *Neogobius melanostomus* obtained from Lake Karaboğaz.

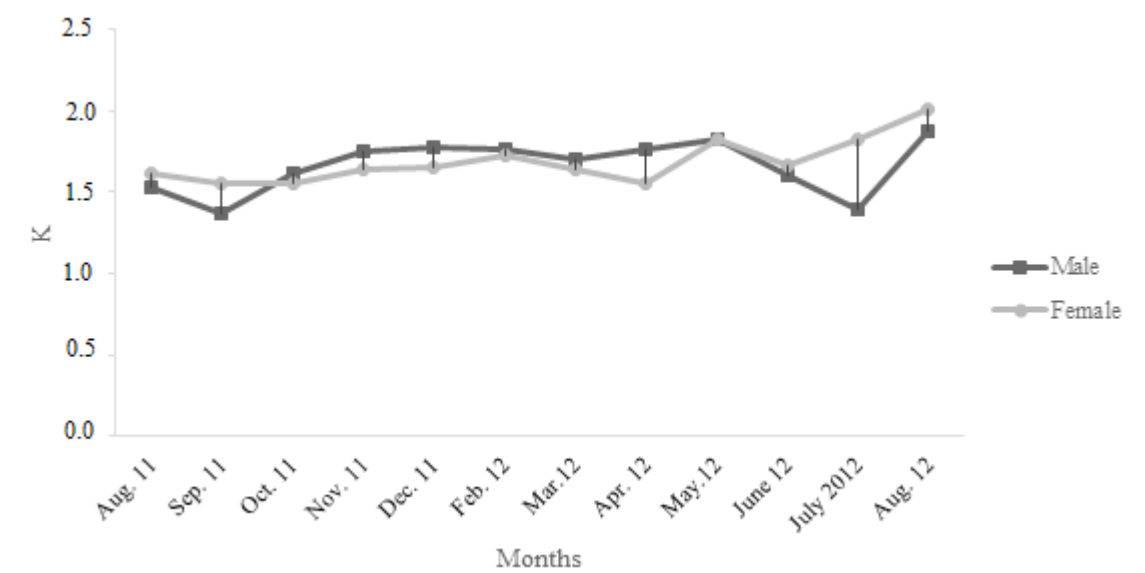|	GL		GW	
Age	Female	Male	Female	Male
1	16.6	13.7	21.5	29.3
2	7.4	8.6	18.7	32.3
3	6.5	7.4	21.9	25.9
4	-	-	-	-

Figure 2. The change of the condition factor by months in *N. melanostomus* individuals obtained from Lake Karaboğaz.

Table 3. The change of the sex ratio by ages in *N. melanostomus* individuals obtained from Lake Karaboğaz.

	Male		Female		Sex Ratio
Age	N	%N	N	%N	F:M
I	13	56.5	10	43.5	0.8:1
II	91	68.9	41	31.1	0.5:1
III	44	51.8	41	48.2	0.9:1
IV	16	61.5	10	38.5	0.6:1

4). The highest and lowest total fecundity were determined in age group III (2477) and age group IV, respectively. In addition, egg-bearing individuals were also determined in the age group I (2008) (Figure 5).

DISCUSSION

The growth and reproduction characteristics of *N. melanostomus* were examined in this study carried out in Lake Karaboğaz between August 2011 and August 2012. For this purpose, the age composition of *N. melanostomus* samples living in the lake was firstly determined. The age group III was found to be dominant (48.2%) in female individuals and age group II (68.9%) in male individuals (Table 3). Slastenenko (1955-1956) stated that *N. melanostomus* individuals usually reached up to 3-4 years of age and sometimes reached ages older than 4 years [1]. In this study, the age values obtained from Lake Karaboğaz were compared with the results of other studies carried out in order to reveal the growth characteristics of the species in question, and it was determined that the maximum age range reached by the *N. melanostomus* individuals living in different regions varied between 2-6 (Table 4). It is observed that the highest age group of *N. melanostomus* is determined in the Baltic Sea with high salinity and that the lowest age group is determined in rivers that are freshwater systems. Sokolowska and Fey (2011) stated that this situation was due to salinity and thus, the species in question showed a better development in salinated environments [33]. While the mean salinity of the Baltic Sea is 7‰ [35], the mean salinity of Lake Karaboğaz measured between August 2011 and August 2012 is 2.5‰. This result supports the relationship between salinity and the growth of *N. melanostomus*. The age values obtained from Lake Karaboğaz, that is located within the Black Sea-Caspian and Aral system, are compatible with the age values of other fish populations within the system in question. Consequently, it is observed that the age distribution of the *N. melanostomus* population living in Lake Karaboğaz is between the expected values in the systems where the species is naturally found.
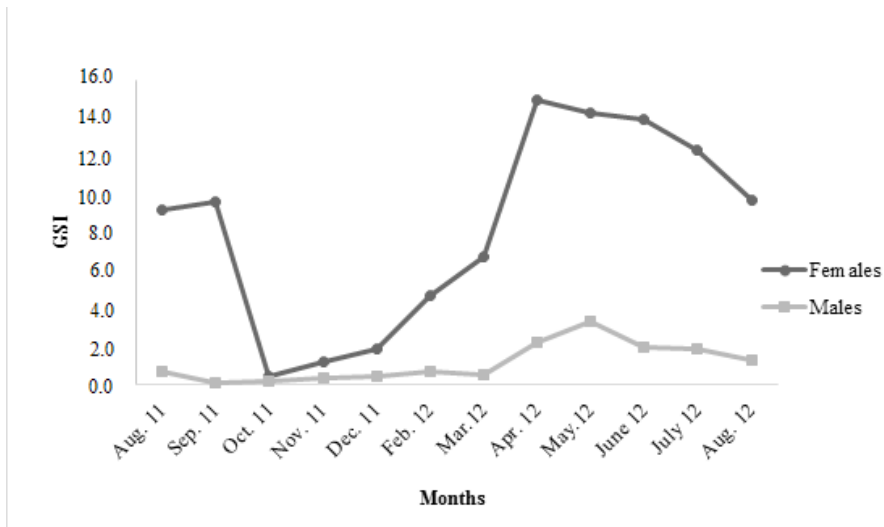
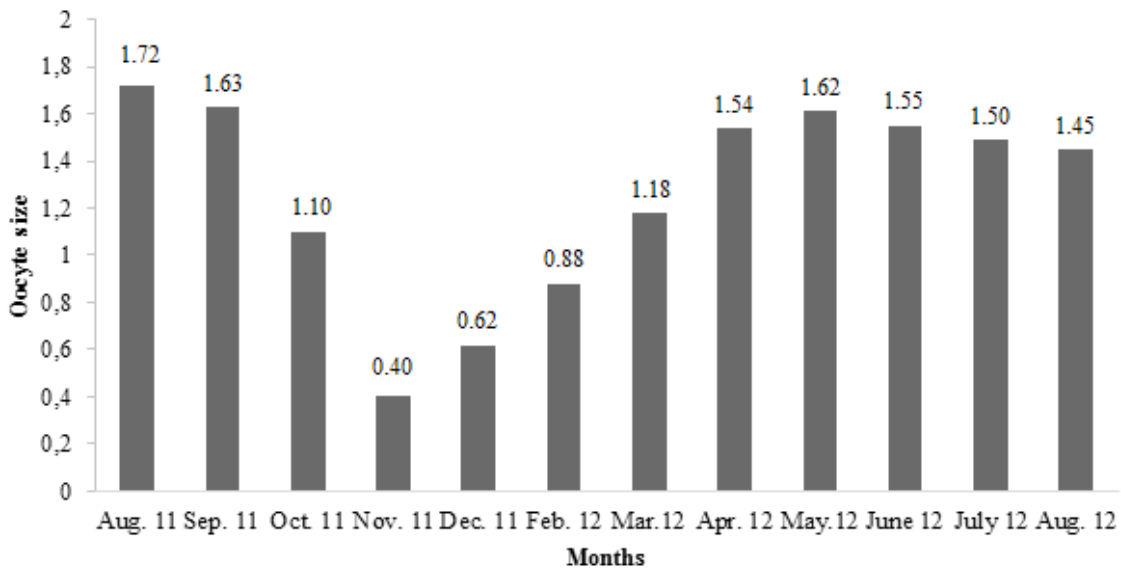**Figure 3.** Monthly change of the mean GSI values of *N. melanostomus* obtained from Lake Karaboğaz.

Figure 4. Monthly change of the egg diameter in *N. melanostomus* individuals obtained from Lake Karaboğaz.
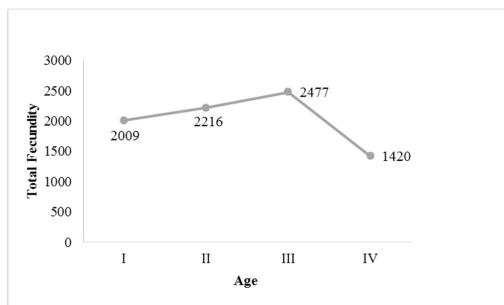

Figure 5. Monthly change of the total fecundity in *N. melanostomus* individuals obtained from Lake Karaboğaz.

The mean length value of the population was determined to be 136 mm. The mean total length values by age groups are 111 mm at age I, 132 mm at age II, 142 mm at age III and 159 mm at age IV, respectively. The total length values obtained in this study were compared with the total length values obtained from other studies carried out on the growth of the species in question (Table 5). Slastenenko (1955-1956) stated that the total length value of *N. melanostomus* individuals could reach up to 250 mm [32]. Upon examining Table 5, it is observed that the maximum total length value of *N. melanostomus* is 250 mm (the Baltic Sea) and the minimum total length value is 98 mm (the Danube River, Yugoslavia). Regarding to total length values,

Table 4. Age distribution of *N. melanostomus* populations living in different regions (as cited in Sokolowska and Fey, 2011).

Study site		Maximum Age	Researcher
Baltic Sea	Gda sk Bay	6	Sokolowska and Fey (2011) [33]
	Gda sk Bay	5	Skóra & Stolarski (1996) [37]
	Gda sk Bay	4/5	Wandzel (2000, 2003) [38,39]
	Gda sk Bay	4	Sapota (2006) [11]
	Gda sk Bay	4	Grygielewicz (1998) [40]
	Gda sk Bay	5/4	Mierzwicka (2000) [41]
	Vistula Lagoon	3	Pliszka (2002) [42]
Southern Europe	Danube River basin, Serbia and Yugoslavia	3	Simonovi et al. (1998, 2001) [43,44]
Eastern Europe	Kuibyshev Reservoir, Central Volga, Russia	4	Shemonaev & Kirilenko (2009) [45]
Great Laurentian Lakes Basin	Upper Detroit River	3	Macinnis & Corkum (2000) [14]
	Lake Erie, Pennsylvania Tirbutary River	4	Phillips et al. (2003) [46]
Black Sea-Caspian and Aral system	Caspian Sea	3	Nikolskii (1963) [3]
	The Sea of Azov	3/4	Slastenenko (1955-1956) [1]
	The Sea of Azov	4	Berg (1949) [47]
	The Sea of Azov, Utluk Lagoon	3	Berg (1949) [47]
	The Sea of Azov	2	Trifonov (1955) [48]
	The Sea of Azov	3	Kostyuchenko (1961) [49]
	The Sea of Azov	3	Apanasenko (1973) [50]
	The Sea of Azov	3	Smirnov (1986) [51]
	Black Sea, Crimea	4	Apanasenko (1973) [50]
	Black Sea, Tiligul Lagoon	4	Apanasenko (1973) [50]
	Karaboğaz Lagoon, Turkey	4	The Present Study

as well as in the age distribution, the highest and lowest values were respectively observed in marine systems with high salinity, and freshwater systems with low salinity. These data obtained are consistent with the opinion of Sokolowska and Fey (2011) that the growth of *N. melanostomus* is related to salinity [34].

According to the von Bertalanffy growth model, it was determined that male individuals grew faster (Female $L_∞$ = 15.44, Male $L_∞$ = 19.96). In all other studies carried out, it w that the total length values of male individuals were higher than the total length

values of female individuals in the same age group and that they grew faster. Nikolskii (1963) stated that the male individuals of the species in question grew faster than female individuals and could reach larger sizes [3].

When the GL values of female and male individuals were examined separately, it was determined that both individuals had the highest OBA value at age I. When the GL values of the sexes according to age groups were examined, it was determined that the GL values of male individuals were higher compared to female individuals in all age groups ex-

Table 5. Total length values of *N. melanostomus* individuals living in different regions (as cited in Sokolowska and Fey, 2011).

Study site		Total Length (mm)	Age							Researcher
			0	1	2	3	4	5	6	
Baltic Sea	Gda sk Bay	235	-	-	119	136	146	155	209	Sokolowska and Fey (2011) [33]
	Gda sk Bay	246	-	-	152	182	212	x	-	Skóra & Stolarski (1996) [37]
	Gda sk Bay	250	-	53	105	158	173	-	-	Sapota (2006) [11]
	Gda sk Bay	214	-	65	118	152	176	-	-	Mierzwicka (2000) [41]
	Vistula Lagoon	182	-	87	135	169	-	-	-	Pliszka (2002) [42]
Southern Europe	Danube River basin, Serbia and Yugoslavia	98	42	77	93	x	-	-	-	Simonovi et al. (1998, 2001) [43,44]
	Middle Danube River, Slovakia	153	x	x	x	x	x	x	x	L'avrin iková et al. (2005) [52]
Eastern Europe	Kuibyshev Reservoir, Central Volga, Russia	135	x	x	x	x	x	x	x	Tysplakov (1974) [53]
	Kuibyshev Reservoir, Central Volga, Russia	168	78	120	133	157	x	-	-	Shemonaev & Kirilenko (2009) [45]
Great Laurentian Lakes Basin	St Clair River, Michigan	118	x	x	x	x	x	x	x	Jude et al. (1992) [54]
	Upper Detroit River	124	-	63	76	-	-	-	-	Macinnis & Corkum (2000) [14]
	Lake Erie, Pennsylvania Tirbutary River	112	44	68	80	-	x	-	-	Phillips et al. (2003) [46]
Black Sea-Caspian and Aral system	Caspian Sea	190	-	69	88	111	138	-	-	Nikolskii (1963) [3]
	The Sea of Azov	250	-	130	-	-	180	-	-	Berg (1949) [47]
	The Sea of Azov	140	-	93	102	-	-	-	-	Apanasenko (1973) [50]
	Black Sea, Crimea	150	-	54	88	104	116	-	-	Apanasenko (1973) [50]
	Black Sea, Tiligul Lagoon	130	-	80	88	-	-	-	-	Apanasenko (1973) [50]
	Karaboğaz Lagoon, Turkey	136	-	111	132	142	159	-	-	The Present Study

cept the age group I. Wootton (1990) stated that the length increase value, which is high in the first years, reaches sexual maturity and slows down due to the fact that the large part of food and energy is separated between activities such as the development of the gonads and the formation of sex cells [29]. It is thought that the fact that the GL values of male individuals are higher compared to female individuals in all age groups except the age group I is due to the separation of energy between gonads along with the fact that female individuals reach sexual maturity. Indeed, as a result of this study carried out in Lake Karaboğaz, it was determined that the female individuals and male individuals of *N. melanostomus* reached sexual maturity in the age group I and in the age group II, respectively.

When the weight values were examined by sexes, it was determined that the lowest weight and the highest weight in female individuals were 12 g and 82 g, respectively, and the lowest weight and the highest weight in male individuals were 13 g and 119 g, respectively. Yankova et. al. (2011) stated that the mean weight value of *N. melanostomus* individuals sampled from the Black Sea coast of Bulgaria was 58.1 g, the minimum weight value was 37.5 g and the maximum weight value was 113 g [34]. When these data are examined, it is observed that the weight values of *N. melanostomus* individuals living in Lake Karaboğaz are compatible with the populations living in other regions. Whether this difference determined between sexes in terms of weight was

statistically significant was tested with ANOVA. The test results revealed that the mean weight difference between sexes was significant in all age groups. Slastenenko (1955-1956) stated that the weight values from the age I to the age II observed in female and male individuals of *N. melanostomus* population living in the Sea of Azov were 29 g, 41 g and 74 g, respectively, in female individuals and 37 g, 71 g and 106 g in male individuals, respectively [32]. When these values are examined, it is observed that the weight values of male individuals are higher than the weight values of female individuals in all age groups.

The value of the condition factor (K), which is calculated over both the length and weight parameters and reflects the growth characteristics of fish populations, gives information about the nutritional power or nutritional level of the environment in which the fish is present, and is a very important growth parameter that allows for the comparison of populations of the same species living in different localities. This value also allows for their comparison in different age and sex groups within the same population by seasons and even months. The mean K value of 266 *N. melanostomus* samples caught from Lake Karaboğaz was calculated to be 1.64.

In general, it was determined that the K value of male individuals was higher than the K value of female individuals. It was found out that the highest K value was 1.69 in age group II in female individuals and 1.79 in age group IV in male individuals. The lowest K value was found in September in both females and males. Growth in fish varies depending on many factors such as the amount of nutrients in the water, competition with other fishes, where the fish reaches sexual maturity, age and size, and is unique to the species and the development phase of the species [3].

N. melanostomus has entered the inland waters of Europe and North America both by the ships' balancing water or migrating through the rivers although they are naturally found in the Sea of Azov, the Black Sea and the Sea of Marmara [20]. The growth values of *N. melanostomus*, that do not give much importance to salinity, temperature, food and the area where they live, obtained from Lake Karaboğaz were comparatively

discussed with the populations living in other regions, and it was determined that the growth was slower than the expected values in natural fish populations.

When the sex ratio of *N. melanostomus* individuals obtained from Lake Karaboğaz is examined, it is observed that male individuals are dominant in the population. Nikolskii (1963) stated that the ratio between sexes is close to 1:1 in many species in healthy fish populations [3]. The fact that the sex ratio of *N. melanostomus* individuals living in Lake Karaboğaz is different from the expected value in natural fish populations is due to the fact that fishing is performed in the spawning area of the species to determine the reproduction characteristics of the species in question. Slastenenko (1955-1956) stated that male *N. melanostomus* individuals did not leave the nest to protect eggs until larvae were hatched, and female individuals plumbed the depths of the sea to feed as soon as they laid eggs [1].

It was determined that the female and male individuals in the *N. melanostomus* population living in Lake Karaboğaz started to reach sexual maturity from the ages I and II, respectively. Nikolskii (1961) stated that the female and male individuals of *N. melanostomus* reached sexual maturity at the ages of 2 and 3, respectively [20]. Macinnis and Corkum (2000) found that most of *N. melanostomus* female individuals living in the Detroit River reached sexual maturity at the age of I and in smaller sizes compared to the populations living in Europe [14]. Nikolskii (1963) indicated that the age of reaching sexual maturity was closely related to biotic and abiotic factors affecting the growth such as water temperature and the abundance of nutrients in the environment as well as the climatic and geographical characteristics of the area [3]. According to these data, it was observed that the age of reaching sexual maturity of *N. melanostomus* individuals caught in Lake Karaboğaz was in the expected age range.

The highest GSI value was determined in April in female individuals by 15.0 and in May in male individuals by 3.3. Macinnis and Corkum (2000) found the highest GIS value in female individuals of *N. melanostomus* living in the Detroit River to be

9.0 [14]. The GSI value of the female individuals of *N. melanosotomus* living in Lake Karaboğaz is quite high compared to these values. It is thought that the difference in the GSI indexes of *N. melanostomus* individuals sampled from different habitats is due to the fact that they depend on many factors such as the amount and quality of the nutrition consumed in the development of gonads, amount of light and temperature.

The determination of the reproduction period using the GSI values in *N. melanostomus* species is more successful compared to the other species of the Gobiidae family [14]. When the GSI values of female and male individuals were examined by months, it was determined that the GIS value in both sexes decreased in September and October and reached the highest value in April-May. According to this result obtained, it was determined that the reproduction period of *N. melanostomus* started in April and ended in September. Charlebois et al. (1997) indicated that the reproduction period of *N. melanostomus* individuals usually started in March, April and continued until September and that the reproduction period in different regions ended in June (Romania), July (the Aral Sea) or September (Varna) [20].

When the egg diameters of the female individuals of *N. melanostomus* living in Lake Karaboğaz were examined, it was determined that the highest value was in May (1.62) and the lowest value was in November (0.40) and that the egg diameter increased continuously in the months after November.

It was determined that the number of eggs of *N. melanostomus* individuals was between 1420-2477. It was found out that the number of eggs increased with age in the other age groups except for the age group IV. Although the small number of eggs in the age group IV is not an expected result, this result is thought to be due to the small number of individuals in the age group in question (n= 10). Slastenenko (1955-1956) stated that the number of eggs of *N. melanostomus* female individuals living in the Sea of Azov varied between 325-3323 while Macinnis and Corkum (2000) stated that the number of eggs of the population living in the Detroit River varied between 310-5210 [1,14]. Charlebois et. al. (1997) stated that the number of eggs of *N. melanostomus*

individuals living in the European waters was between 200-9771, and the number of eggs in some individuals could reach up to 10.000 [20]. Corkum and Macinnis (2000) stated that the egg yield of *N. melanostomus* individuals was generally low but they achieved success along with the high hatching rate of eggs and the fact that males kept watching for the nest [14]. When these data were analyzed, it was observed that the egg yield results obtained from Lake Karaboğaz were compatible with the natural populations of *N. melanostomus* spawning at a water temperature of 9-26°C.

In conclusion, it was determined in this study carried out in Lake Karaboğaz, which is a shallow lagoon lake, that the growth values of *N. melanostomus* were lower than the expected intervals in the environments where they were locally present. The growth values of the population of this species, living in Lake Karaboğaz are lower than sea basins and higher than freshwater basins. It is believed that the reason for this is due to the fact that the *N. melanostomus* origin is marine but it is a secondary fresh water species. The fact that the number of eggs was less than the expected values is due to the fact that the species is locally present in Lake Karaboğaz and does not exhibit an invasive characteristic in its environment. These results are important for understanding the biology of the species and the breeding of the species in habitats where they are invasive.

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