African Journal of Biotechnology Vol. 10(73), pp. 16674-16681, 21 November, 2011
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB10.2502
ISSN 1684–5315 © 2011 Academic Journals

Full Length Research Paper

Alien fish species in upper Sakarya River and their distribution

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Accepted 24 October, 2011

Sakarya River is one of the most important fishing areas in Turkey. The river provides reproduction and survival areas which are suitable for many fish species by means of both the warm water sources and the wide flood plains. However, the fact that the flood plains have been reclaimed, excessive hunting, destruction of the ecologic balance and invasion of the area by the alien fish species threatens the fish stocks in Sakarya River. In this study, we aimed to determine the dispersion area of *Carassius gibelio* (Bloch, 1782), *Oreochromis niloticus* (Linnaeus, 1758) and *Clarias gariepinus* (Burchell, 1822) as the alien fish species. Between years 2005 and 2010, the dispersion areas of these three species in Sakarya River have been determined by means of catching in irregular time periods in the entire Sakarya River. The dispersion details of every of the three species has been yielded with this study for the first time and the natural populations created by *O. niloticus* in Sakarya River was determined for the first time in this study.

Key words: *Carassius gibelio*, *Oreochromis niloticus, Clarias gariepinus,* Sakarya River.

INTRODUCTION

Depending on the fast increase of the human population and the negative effect of the industry on the fields where agricultural production is performed, the food supply and demand balance in the world dramatically increases in the route of demand. One of the actors used for providing this balance is the fish production in fresh water environments. The fresh water areas capable of fish production are also very limited in the world. Therefore, various studies are conducted in order to obtain the best result from the smallest unit area. The most important of the studies carried out include cultivation of the species rendering the highest productivity or increasing the amount of production by enabling their adaptation into an aquatic environment where these species have never lived before. The cultivation and adaptation studies are generally conducted by the Universities and government oriented research institutions. As a consequence of these studies, many species were successfully cultivated and serious resource has been provided to the production. However, these studies which begin with good purposes have led to ecological aftermaths. The species which are not found in the natural fauna of the country in Turkey were brought from oversea countries particularly like Africa or were conveyed from the region where it was naturally found in Turkey to the other regions and studies have been conducted on the adaptation of these species into their new habitats.

Clarias gariepinus (Burchell, 1822) was moved from a very small area in the south of Turkey to Sakarya River for the purposes of scientific studies and nowadays began to threaten the wetland ecology in Sakarya River basin by demonstrating a high level of adaptation to its new habitat.

The natural area of spread is Niger and Nile River; however, it is still dispersed to all over Africa. It was introduced to some regions in Europe (Elvira, 2001). It is widely introduced to other parts of Africa, Europe and Asia. Several countries report adverse ecological impact after introduction. The main area of distribution in Turkish waters is the ASI River Basin and is referred to as *Clarias lazera* from the Asi River (Orontes River) in the ancient records (Geldiay and Balik, 1988) and probably was consciously or unconsciously carried or introduced to Çukurova, Göksü (Mersin) and Antalya wetlands. It is stated that the individuals noticed from Antalya wetland were grafted by D. S. İ. (General Directorate of State

Hydraulic Works) (Küçük and İkiz, 2004). Furthermore, it was recorded in 2001 in Sakarya River and in 2007 in Göksu River (Yalçin et al., 2001; Küçük et al., 2007).

Oreochromis niloticus (Linnaeus, 1758) is currently the most widely cultivated finfish in Africa (Graaf and Janssen, 1996). The tilapias which are not naturally found in Turkish waters were brought from Israel and England first by D.S.İ. then by Faculty of Agriculture in Çukurova University and were tried to be adapted to the region in the late 1970s (Tekelioğlu, 1991).

The most significant restrictive factor for this species is the low temperatures which particularly occur in winter months. They mostly cannot survive in temperatures under 13 to 14°C. In the early 1980s, the tilapias produced in the water fish manufacturing station of the Faculty of Agriculture in Çukurova University, escaped from the evacuation channels of the station and created a population in the Seyhan River regions close to the Mediterranean Sea (Dikel, and Çelik, 1998). Based on this study, the first records which indicated that *O. niloticus* lived and created a population in the region defined as Sakaryabaşi in the upper Sakarya River wetland were received.

Eggs and fries, which belong to 25 exotic species, have been introduced in Turkish waters for various purposes for more than fifty years. One of these exotic species is *C. gibelio* (Bloch, 1782) (İnal and Erk'akan, 2006). This species is common in Western Asia, Siberia and the entire Europe (Kottelat, 1997). However, it is not one of natural species in European continent (Flajshans et al., 2008). Only its occurrence in Northern Europe may be natural (Kottelat, 1997). Mikelsar (1984) reported that *Carassius gibelio* species was transferred from Asia to Europe in the 17th century (Vetemaa et al., 2005). This species is already established in at least 12 European countries (Özcan, 2007). Daget and Economidis (1975) reported that this species existed in River Maritza in Western Thrace (Sari et al., 2008). *C. gibelio* entered into Turkey through River Maritza over Greece or Bulgaria or it was carried by people (Özuluğ, 2004). In 1988, this species was reported by Baran and Ongan in Gala Lake in Thrace region from Turkey for the first time (Özuluğ, 1999). 10 to 15 years after this species was observed in Thrace region in Turkey, it was reported from 46 fresh water systems in Thrace and Anatolia (Özcan, 2007). Based on this study, *C. gibelio* was first reported in the upper Sakarya River basin other than Porsuk stream. Today, all fresh water systems in Turkey are subjected to a threat of invasion by *C. gibelio*.

The purpose of this study was to determine the distribution of Sakarya river alien fish species.

MATERIALS AND METHODS

Sakarya River is the 3rd longest river in Turkey. The river basin covers approximately 7% of the territories Turkey with a surface area of 56,504 km^2. The length of the river is 810 km (Şengörür and Isa, 2001). Sakarya River rises from many springs from the mountain slopes in Balat plateau in Emir Mountains from the northeast of Afyonkarahisar. However, the area where three springs excrete in 5 km southeast of the county of Çifteler in the city of Eskişehir is accepted as the main spring region. This area is identified as Sakaryabaşi by the local people. Two of these three springs is a cold water source and one of them is a hot water spring. The water temperature changes between 16 to 24°C throughout the year. The Sakarya River basin is examined in three groups under the names of upper, middle and lower Sakarya River basin in hydrological terms (D.S.I., 1992).

In order to determine the distribution of the alien species determined in the upper Sakarya River basin, many field studies have been conducted in the region between the years 2005 and 2010. In order to determine the distribution of the alien species in the area studies, samples have been provided from the people engaged in trade and sportive hunting in the region besides catching fish using electroshocker, galsama nets, roller fishhook and scoop net in order to determine the distribution of the alien species in the area studies. During this study, the existence of the species was examined in 26 different locations above the upper Sakarya River (Figure 1).

In the 1970s, since the channel of Sakarya River was deepened by D.S.I., the electroshocker tool could only be used in Seydi water. The samples in Kunduzlar and Çatören dams were provided by the fishing cooperative in the region. In the region between Çifteler, Sakaryabaşi and Uşakbükü, galsama nets, roller fishhooks and scoop nets were used, however, since the region is rather wide, samples were also procured from the commercial fishermen in the region. Furthermore, in the region as rich in terms of Cyprinid and Pike, sportive fishing continues intensively. Samples were also been procured from the amateur fishermen during the studies.

RESULTS

The localities and intensity of the alien species caught from the 26 stations are given in Table 1 and their status on the river basin is given in Figure 1. The frequency of the availability of the fish in the localities was determined considering the seasonal ratios and the frequency observed on the net for that species. If it was the 1st, 2nd or 3rd species that was most caught on the net for the four seasons, it was referred to as 'high'; but if it was not observed frequently in cold seasons such as winter, it was referred to as 'medium' and if it was not the 3rd species that was mostly caught in the net but was observed sometimes, it was referred to as 'low'.

Particularly, *C. gibelio* was the most frequently encountered fish species in the upper Sakarya region, which indicates that the entire upper Sakarya region was under *C. gibelio* invasion. *C. gariepinus* was mostly observed in the main spring ponds in Çifteler and in Balik dam with a high level of concentration. It was particularly observed in the region between Sakaryabaşi and Eminekin where the water was warmer in winter months and in the regions of Balik dam where the water demonstrated the highest level of distribution. Together with the spring months, it was observed in the entire region between Sakaryabaşi and Balik dam. It was observed in several numbers in the watering areas which became shallower particularly in spring months.Both *C. gibelio* and

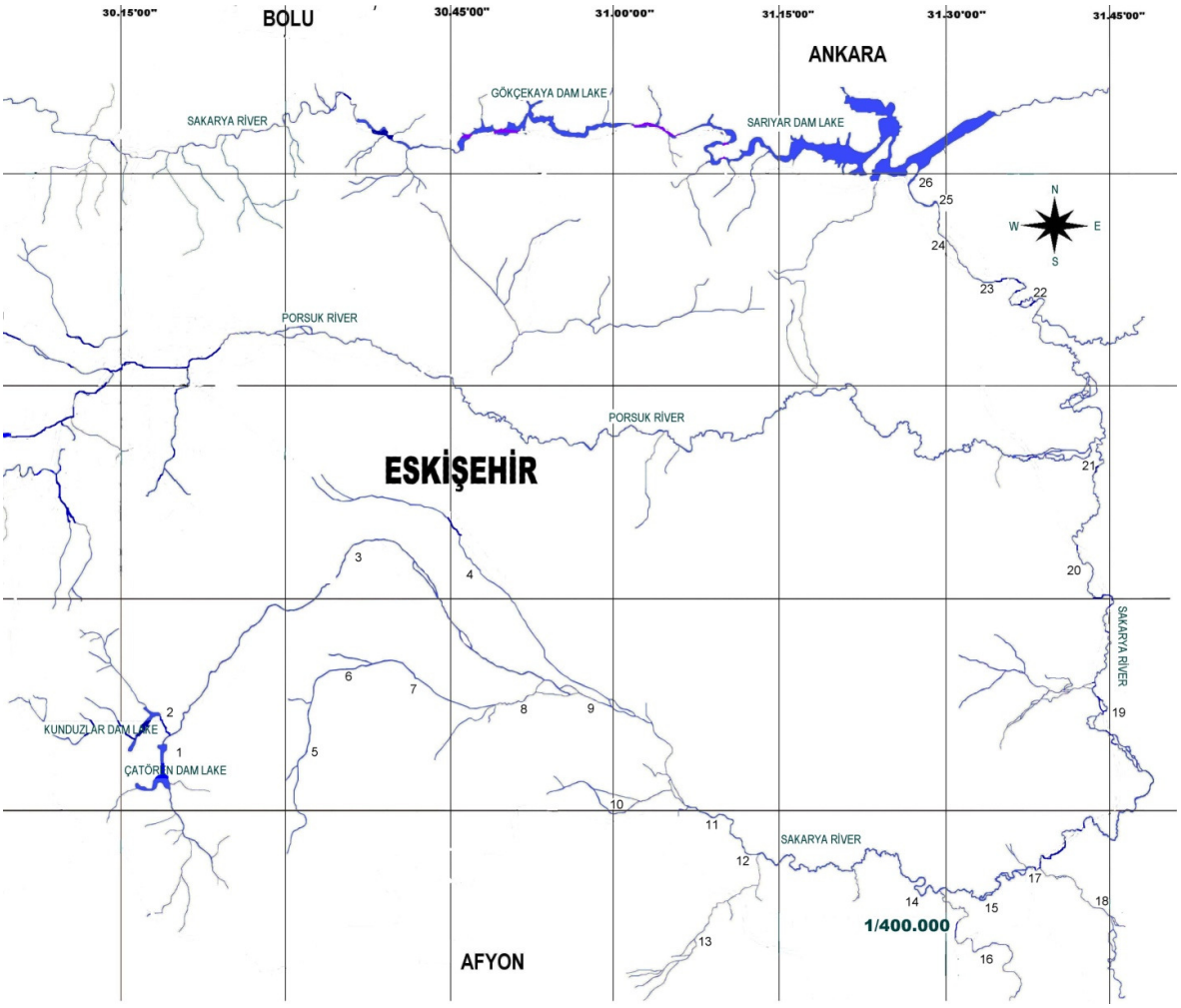

Figure 1. Upper Sakarya River Basin.

C. gariepinus were observed in relatively less number in İlyas Paşa region which is very close to Balik dam. During hunting operations in this region, a great number of *Esox lucius* Linnaeus (1758) was caught. The natural species of the Sakarya River *E. lucius* superseded the other two invaders by intensifying in this region. However, *E. lucius* which was seen in almost all over the upper Sakarya River basin before was squeezed in a narrow area between Balik dam and İlyas Paşa.

Since the distribution of *O. niloticus* was limited by the water temperature, it was observed that this species was disseminated only in the 5, 6, 7, 8, 9 and 10th station.

DISCUSSION

C. gariepinus is a fish with a North Africa origin. *C. gariepinus* entered into the Turkish waters via Asi river system and Pliyosen is the local species of Turkey which was adapted to this region upon cease of the connection of the Asi River with Africa. However, because of the Anatolian diagonal and ecological restriction, it is a species which does not demonstrate a natural dissemination in Turkey either other than Asi River. However, since it displayed a high level of success in cultivation particularly in the North Africa, it was grafted into many fresh water systems in Europe. However, it could not create successful populations in many water systems it was carried to. The success of this species in waters where it was grafted depends on the water temperature. Various experimental studies have been carried out in Turkey related with this species. It was grafted in the Antalya region by D.S.İ. and created successful populations (Küçük and İkiz, 2004).

In the study carried out in waters poured into Antalya gulf, the first largest sample of 38 cm was caught (Küçük and İkiz, 2004). In this study, the first sample of 62 cm was caught from Balik dam region in August 2010. As long as it was not carried by human, it was not possible for this species to reach the Sakarya River. Studies on this species were carried out in Sakaryabaşi Fish Manufacturing and Research Station of Ankara University

Table 1. Locality status and distribution of the alien species in these areas.

Lokalite	Location number		Species					
			C. gariepinus		*O. niloticus*		*C. gibelio*	
			Existent	Density	Existent	Density	Existent	Density
Çatören Dam Lake	1	39°18'N 30°34'E	-	-	-	-	+	H
Kunduzlar Dam Lake	2	39°20' N 30°33' E	-	-	-	-	+	H
Hamidiye	3	39°33' N 30°55' E	-	-	-	-	+	L
Doğanca	4	39°32' N 31°01' E	+	L	-	-	+	M
Çifteler Pond 1	5	39°22' N 31°04' E	+	H	+	M	+	M
Çifteler Pond 2	6	39°22' N 31°05' E	+	H	+	M	+	M
Çifteler Pond 3	7	39°22' N 31°06' E	+	H	+	H	+	M
Eminekin Pond	8	39°21' N 31°06' E	+	H	+	L	+	L
Körhasan	9	39°23' N 31°11' E	+	M	+	L	+	H
Başkurt	10	39°16' N 31°08' E	+	H	+	M	+	H
Gülçayir	11	39°14' N 31°24' E	+	M	-	-	+	H
Buzluca	12	39°12' N 31°27' E	+	M	-	-	+	H
Veysel	13	39°06' N 31°23' E		-	-	-	+	M
Ahiler	14	39°11' N 31°37' E	+	H	-	-	+	H
Balik Dami	15	39°12' N 31°37' E	+	H	-	-	+	H
Fettahoğlu	16	39°09' N 31°38' E	+	H	-	-	-	-
Ilyas paşa	17	39°09' N 31°43' E	+	L	-	-	+	L
Söğütoğullari	18	39°04' N 31°51' E	-	-	-	-	+	L
Gülpinar	19	39°10' N 31°52' E	-	-	-	-	+	M
Kabak	20	39°15' N 32°02' E	-	-	-	-	+	M
Beylikköprü	21	39°35' N 31°56' E	-	-	-	-	+	H
Dümrek	22	39°51' N 31°52' E	-	-	-	-	+	H
Kargi	23	39°57' N 31°44' E	-	-	-	-	+	H
Eyren	24	39°58' N 31°42' E	-	-	-	-	+	H

Table 1. Continue

Sazak	25	40°25' N 32°04' E	-	-	-	-	+	H
Uşakbükü	26	40°00' N 31°40' E	-	-	-	-	+	H

/*-
L, Low; M, medium; H, high.

Faculty of Agriculture Department of Water Products in Sakaryabaşi in the 1980s. Probably the fish used in this study either escaped to the river or entered to the river after been released as a result of the studies. Balik Dam where very shallow and wide wet lands are formed particularly from month April to the month September is an ideal area of development for the Cyprinidae fries. The mature fish cannot enter these regions since the water is very shallow and cannot hunt these small individuals. However, together with the adaptation of *C. gariepinus* species into Sakarya River, the status of the Balık dam for being a fish fry manufacturing center has weakened, since the *C. gariepinus* individuals freely came to this region where only the fish fries live and caused great damage on fish fries despite this region is shallow. During this study, it was observed that many *C. gariepinus* individuals hunted the fish fries in the waters in the area of flood.

Together with the other ecological negativities, the existence of *C. gariepinus* has become the most significant factor threatening the fish population in the upper Sakarya River. The ability to walk towards water on the pectoral fins caused a negative attitude to develop among the local people against this species. Furthermore, the fact that the local people are not used to the taste of its flesh and the proper processing methods are not generally known, this species is not preferred as food by the local people. Since a comprehensive ichthyology study was not carried out in the region for the last 10 years, no detailed information is available about the ecological niche of this species in the region.

O. niloticus is a species with the highest rate of manufacturing after rainbow trout and carp in the world. First China and then the Asian countries are the largest tilapia manufacturers and consumers. The manufacturing of tilapia fish has exceeded 2.5 million tones based on the 2005 data (Fitzsimmons, 2008). Tilapia is the most important fish species which is raised in the world today. Based on some resources, it is the second most raised species in the world. Today, tilapia occupies the third row after shrimps and Atlantic salmon as the sea species which are most imported by the U.S.A. (Bhujel and Suresh, 2000; Alceste and Darryl, 2001). *O. niloticus* as a member of the Chiclidae familia which is raised in tropical and subtropical climates is a species which is not naturally dispersed in Turkey. However, approximately 30 years ago, the raising of this species in Adana region began (Sarihan, 2005).

The tilapia was brought first from Israel and then from England by D.S.İ and Çukurova University Faculty of Agriculture to this region and adaptation studies were carried out (Tekelioğlu, 1991). The first population in the natural waters specified in the literature was formed in Seyhan River upon their escape from the internal water fish manufacturing station of Çukurova University Faculty of Agriculture in the early 1980s (Dikel and Çelik, 1998). This species has become an important issue of the fish cultivation studies in Turkey since it has a high rate of trading in the world.

Because of its extreme reproduction potential, it is a potentially harmful species (Çetinkaya, 2006). It was noticed that they form populations which can still reproduce in Çukurova waters, Asi River, Hirla Lake, Köyceğiz Lake and threatens the other species by dominating in Köyceğiz Lake (Celik and Gokce, 2003; Başusta et al., 1996; Akin et al., 2005). This species can be found in various institutions for raising and scientific purposes. Ankara University Faculty of Agriculture Department of Water Products Fishing Research Unit and Sakaryabaşi-Çifteler Fish Manufacturing and Research Station conducted a study called Examination of the Facilities for Raising Tilapia (*O. niloticus* L.) Fish (Seçer et al., 2008). For this study, 400 *O. niloticus* individuals were brought to the research station in Sakaryabaşi from the Çukurova University Fisheries Faculty. In the literature scanning, no data could be found to indicate any studies on this species in the region or in the station.

Moreover, the date when the *O. niloticus* individuals were brought to the station was not indicated. This species were brought from Çifteler municipality in 1995 for the first time and left to the region called East pond in Sakaryabaşi. In that period, this species was unable to pass through the pond, which had a barrage from the main spring, to this type of a main channel. However, upon destruction of the barrage for environment monitoring purposes, this species was dispersed to Sakaryabaşi. It is observed that they have created large colonies comprising hundreds of individuals in the regions where Eminekin barrage is present particularly in summer, autumn and winter months. Since it resembles sea bream in terms of appearance, it is named as fresh water bream by the local people.

The most significant factor limiting the cultivation of this species, which can be raised in tropical and subtropical climate zone, is the temperature. This species grows normally above 16°C; reproduces above 22°C; loses activities below 16°C and begins to die at 10°C (Buhujel, 2000). The temperature of the water resources in the region generally changes between 16 to 24°C (Güler, 1988). The ponds created by building a barrage to the

fronts of Sakaryabaşi and Başkurt spring makes up the ideal areas for both development and reproduction of this species in terms of temperature. This species was not encountered in Eminekin and Körhasan regions which are colder in particularly winter. Furthermore, this species was seen more intensively in Çifteler pond 3 with a higher winter temperature compared with the other localities in Sakaryabaşi. Since water temperature is a determining factor for the dissemination of this species, it could spread in a very narrow area. This species is in the lower part of the tropic level and has an herbivore or omnivore feeding feature. The algaes and detrital wastes comprise the fundamental food of these fish. They are notorious with their resistance against diseases and bad quality water conditions (Türker, 2009).

This feeding feature has facilitated their adaptation into the environment. Fast growing and eating particularly, the fish fries make this species a potentially harmful species. Therefore, their development in Sakarya River basin and their effects on the other natural species should be continuously monitored.

C. gibelio is an omnivore type of fresh water fish with an Asian origin which disseminates to the European countries and Turkey in many ways (Specziar et al., 1997). Because of its stringy meat and muddy aroma based on benthopelagic nutrition, the fish is not much preferred by the people. By means of high adaptation power demonstrated in the aquatic environment, it will become the dominant species of that environment soon. It is difficult to be separated from the fries of *Cyprinus carpio* Linnaeus, 1758 (İlhan et al., 2005).

It was noticed that among the individuals created upon stimulation of *C. gibelio* eggs with *C. carpio* sperms, 98% were female, 2% were male and among the bisexual generation created upon multiplication of the male and female individuals 15% were male (Fan and Shen, 1990). It was reported that *Carassius auratus gibelio* reproduces by gynogenesis in the fresh waters in Armenia (Pipoyan and Rukhkyan, 1995); the female individuals which reproduce by gynogenesis and has 150 chromosomes in Pamvotis Lake in Greece were sperm parasites and the other Cyprinidae species reproduce by gynogenesis and therefore 97.7% of the population was comprised of female individuals (Paschos et al., 2004). In Turkey, the population comprising triploid individuals as a result of gynogenetic reproduction feature based on the diameter of erythrocides was reported from Kayaliköy Dam Lake and Porsuk Dam Lake (Kalous et al., 2004; Emiroğlu et al., 2010). The female dominated population structure as an indicator of reproduction by gynogenesis was reported from Ömerli Dam Lake (Tarkan et al., 2006), Bafra Fish Lake (Bostanci et al., 2007), Topçam Dam Lake (Şaşi, 2008) and Buldan Dam Lake (Sari et al., 2008). The gynogenetical reproduction feature of *C. gibelio* provides advantage in its competition with the other species in the aquatic environment they invade (Aydin et al., 2011).

Furthermore, *C. gibelio* may have a negative effect over native fishes in the environment as they reach the length of reproduction in a very rapid way in the first ages, they lay eggs in a considerable quantity and in a long period and they can reproduce by using eggs of male species of other Cyprinidae species. Furthermore, it is a species that may create substantial water quality problems by speeding up mixing of foreign bodies accumulated in the bottom with water as it mixes the benthos of the fresh water environment it dwells in to find food (Emiroğlu et al., 2009). Because of these negative features, *C. gibelio* is a harmful species for the environments they invade.

It is uncertain when and how *C. gibelio* entered in the upper Sakarya River basin. However, this species was frequently encountered in this area in 2005 as the first date of this study. Several numbers of *C. carpio* fries were introduced especially at Sakaryabaşi for several times from the governmental manufacturing facilities by means of the county general directorate of agriculture. Probably the *C. gibelio* fries were inadvertently grated to the site since they resemble the fries of *C. carpio*. *C. gibelio* finding the proper environment for surviving was rapidly adapted to the environment and became the dominant species other than a few areas in Sakarya River basin. They have created very large populations in the other parts of the Sakarya River basin which are not close to the upper side. This species is intensively hunted in particularly Sariyar and Gökçekaya Dams.

Considering the distribution of *C. gibelio* in the upper Sakarya River basin, it has been observed that it is not available in Fettahoğlu locality no 16, it is available in Çifteler pond localities number 5-6-7 in medium level and it is available in Ilyaspaşa and Söğütoğullari localities number 17-18 in a very low number. Locality no 16 is an area where the water is lucent and the depth is 3 to 4 m more. In this region, there is a great number of *C. gariepinus*, *Silurus glanis* Linnaeus, 1758 and *E. lucius*. These 3 species are of a severely predator type. Since the lucidity of the water enable *C. gibelio* to be an easy hunt, it does not enter into this region and probably those which enter are hunted by these 3 predator species. Localities with numbers 5-6-7 are close to the main spring and the water temperature is high. Depending on the temperature of the water, this region is intensively invaded by *C. gariepinus* and *O. niloticus*. Because of the existence of two species one of which can hunt predators and the other can easily hunt *C. gibelio* fries and of the fact that the water is more lucent and deeper than the main Sakarya tributary, these localities are not preferred much by *C. gibelio.* Particularly in 17 localities, there are much more *E. lucius* than the other parts of the Sakarya River. The region demonstrates a refigium character for *E. lucius*. In this region, the intensity of both *C. gariepinus* and *C. gibelio* is low because of the high intensity of *E. lucius*. The 18th locality was more lucent compared with Sakarya channel. Depending on such a high light conductivity of the water, the intensity of *C. gibelio* was

low in this region.In this study, the distribution of the three alien species in upper Sakarya River basin was determined. It was observed that *O. niloticus* was disseminated in a narrow area depending on the water heat but did not threaten the entire river basin except for the natural species in the region. *C. gariepinus* distribution was observed to be fundamentally dependent on the water temperature and on the warm water sources to spend the winter. This species was distributed to wider area compared with *O. niloticus* and it was observed that it threatened the fish fauna in the region where it was disseminated because of its predator feature. Both species were carried to the research station in the region for scientific purposes however, that created populations continuing in the natural environments. In every locality where the water was not lucent, the existence of *C. gibelio* was determined in high amounts. This indicated that the existence of predators and the lucidity of the water are the factors which can affect the distribution of *C. gibelio* species.

The exotic species can become a serious danger in terms of variety of species in the long term by superseding the local species in the fresh water resources because of their wide borders of tolerance. Since every exotic species can bring the exotic microorganisms, emergence of new diseases in the natural species forming the ichthyo-fauna is another serious danger (Uğurlu and Polat, 2007).

The harms of the exotic species have been demonstrated in many studies. The best type of manufacturing in the natural environments is to benefit from the existing species in the maximum level. The forthcoming studies should be in terms of precautions for preventing the distribution of the exotic species and for enabling the continuity of the natural species.

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