



Occurrence and length weight relationship of Indo-Pacific mugilid *Chelon carinatus* (Valenciennes 1836) in four river estuaries of Turkey

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Occurrence and length-weight (LWR) relationships of four populations of *Chelon carinatus* in brackishwater systems of Mediterranean coast of Turkey were reported. A non-indigenous fish species, *C. carinatus* were captured between November 2014 and June 2017 in Ceyhan, Seyhan, Göksu and Manavgat river estuaries. A total of 127 individuals, ranging in size between 11.8 and 20.8 cm total length, 19.0 and 113.6 g weight, were examined. The length-weight relationship for all individuals was described by the following parameters: $a = 0.0076$; $b = 3.1708$ and $r^2 = 0.93$. The results of the current length-weight relationship study show that there is significant difference from the isometric b (3.0) value for all these populations. The length-weight relationships from all localities were reported here for the first time.

[Keywords: Alien species, Brackish water, Keeled mullet, Lessepsian fish, Turkey]

Introduction

The Mediterranean Sea is known to be one of the major hotspots of bioinvasion sites. The completion of the Suez Canal in 1869 marked the beginning of a major event affecting two biogeographical provinces, the Red Sea and the Mediterranean¹. More than 100 alien fish species introduced to the Mediterranean Sea via this canal² and the number of lessepsian immigrants colonizing into the Mediterranean Sea increases continuously.

Mugilidae, comprising of ecologically and commercially important fishes, used as seafood and occurred high diversity and abundance. Fishes of family Mugilidae are permanent and frequently abundant in Mediterranean coastal habitats, estuaries and lagoons³. The Mugilidae family includes 77 species that are widely distributed in tropical and temperate coastal waters⁴.

Nine species [*Chelon auratus* (Risso 1810), *C. carinatus* (Valenciennes 1836), *C. labrosus* (Risso 1827), *C. ramada* (Risso 1827), *C. saliens* (Risso 1810), *Mugil cephalus* Linnaeus, 1758, *Oedalechilus labeo* (Cuvier 1829), *Planiliza abu* (Heckel 1843) and *P. haematocheilus* (Temminck & Schlegel 1845)] of Mugilidae inhabit the inland water, brackish water and marine systems of Turkey. Keeled mullet *Chelon carinatus* (Valenciennes, 1836) is native to the Indian Ocean and has recently spread to the south-eastern Mediterranean from the Red Sea via the Suez Canal

as a lessepsian immigrant fish. It occurs primarily in coastal marine waters, but it is also present in inlets, lagoons and river estuaries⁵. Little attention has been paid to the keeled mullet from Mediterranean coast of Turkey. Some genetic aspect of Keeled mullet was studied by Turan *et al.*⁶. Moreover, Küçükgülmez *et al.*⁷ analyzed the biochemical composition of keeled mullet from the North East Mediterranean Sea.

The length-weight relationship (LWR) parameters are significant in fish biology and can provide information on many aspects of fish population dynamics⁸. Despite the importance of the length-weight relationship in fisheries science, there is very little knowledge on length-weight relationships of *C. carinatus* in Turkey. The aim of the study was to provide information on the occurrences and length-weight relationships of keeled mullet in four rivers.

Material and Methods

Fish samples were caught seasonally in four different river estuaries, namely, Ceyhan, Seyhan, Göksu and Manavgat between November 2014 and June 2017 (11 surveys) with trammel net, fyke net and shore-seine net during the field works for the determination of ichthyofauna of Ceyhan, Seyhan, Göksu and Manavgat river estuaries (Fig. 1). Water quality parameters were measured at each survey site. Temperature (°C), salinity, pH and oxygen concentration were determined by using YSI Pro Plus

water quality meter. Secchi depths were estimated by Secchi disk. Captured fishes were anesthetized, and then fixed in 10 % formalin in the field. The fish density and frequency of occurrence were determined⁹. Fish species were identified to species level following identification keys previously described in the literature¹⁰⁻¹³. Specimens were measured to the nearest 0.1 cm total length and weighted to the nearest 0.01 g total weight. Length-weight relationships were estimated for the total sample according to the equation, $W = aL^b$. Where, W = mass in grams; L = total length in centimeters, a = constant; b = constant described as isometric or allometric

growth type¹⁴. The relationships between the length and the weight of fish in each study area were assessed through linear regression ($\text{Log TW} = \text{Log } a + b \text{ Log TL}$). The slopes of length–weight regressions were compared to 3 using Student’s *t*-test to ascertain if species grew isosymmetrically. All analyses were performed using Past programme.

Results

Density and frequency rates of *Chelon carinatus* in Manavgat, Göksu, Seyhan and Ceyhan river estuaries are given in Table 1. Environmental variables recorded during sampling of *C. carinatus* are given in Table 2.

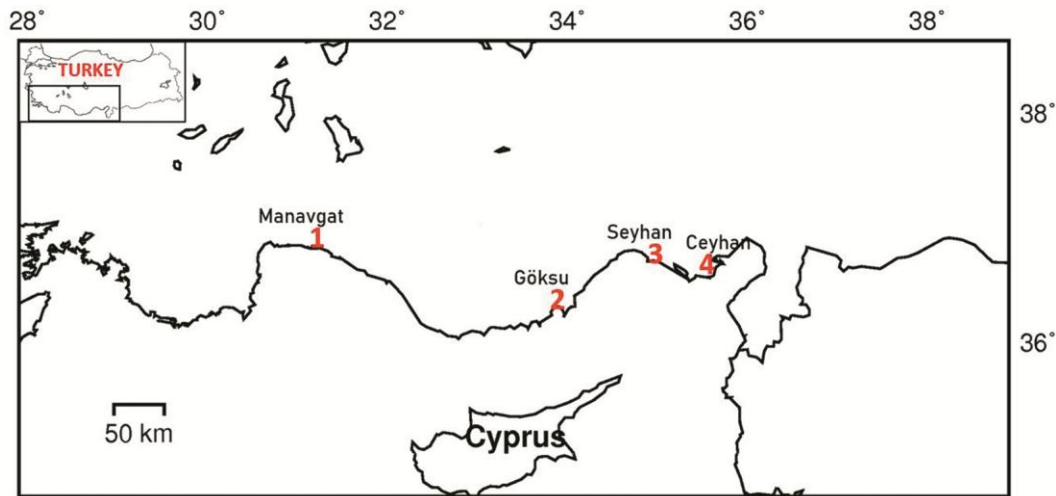


Fig. 1 — Sampling localities

Table 1 — Density and frequency rates of *C. carinatus*

Parameters	Locality (River estuary)			
	Manavgat	Göksu	Seyhan	Ceyhan
Number of Mugilid species	7	6	6	6
Number of Mugilid individuals	5463	3925	4801	4343
Number of <i>C. carinatus</i>	8	9	96	14
Rank of <i>C. carinatus</i> in Mugilid species	7	6	6	6
Density % of <i>C. carinatus</i>	0.15	0.23	2	0.32
Frequency of occurrence % for <i>C. carinatus</i>	18.18 (2/11)	27.27 (3/11)	54.55 (6/11)	9.09 (1/11)

Table 2 — Environmental variables of estuarine systems during only *C. carinatus* sampling

Parameters	Locality (River estuary)			
	Manavgat	Göksu	Seyhan	Ceyhan
Temperature (°C) (surface) (Min-Max)	16.4-20.2	24.1-26.4	12.0-31.0	24
Dissolved oxygen (mg/l) (surface) (Min-Max)	6.9-10.5	3.8-6.5	0.8-8.3	5.1
Salinity (ppt) (surface) (Min-Max)	0.7-0.9	0.2-1.6	0.3-5.4	1.1
Salinity (ppt) (bottom) (Min-Max)	29.3-35.2	27.8-36.2	0.3-35.6	5.6
pH (surface) (Min-Max)	7.3-8.9	7.5-8.4	6.4-8.7	7.2
Secchi disc depth (m) (Min-Max)	0.9-1	0.4-0.5	0.4-0.6	0.4

A total of 18532 fishes representing 7 species of Mugilidae family were collected during the study period: *Chelon auratus*, *C. saliens*, *C. ramada*, *C. carinatus*, *C. labrosus*, *Mugil cephalus* and *Oedalechilus labeo*. The number of Mugilid species in Göksu, Seyhan and Ceyhan river estuaries was 6 in each, while in Manavgat river estuary there were 7 species. Mugilid fish assemblages were mainly comprised of juveniles. In terms of number of individuals, the most abundant species in the estuaries were *C. auratus* (42.5 %), *C. saliens* (26.9 %), *M. cephalus* (15.1 %) and *C. ramada* (13.4 %).

Density of *C. carinatus* has found to be 0.15 %, 0.23 %, 2.0 %, 0.32 % in Manavgat, Göksu, Seyhan and Ceyhan river estuaries, respectively. The frequency rates of *C. carinatus* for estuarine systems ranged from 9.09 to 54.55 %. It is shown in Table 1 that Seyhan river estuary has the highest density and frequency values for keeled mullet.

The majority of individuals (86.6 %) were caught in summer months; 11.8 % individuals were caught in spring months; and the remaining individuals (2.36 %) were caught in winter season.

Size range, estimated LWR parameters, and the coefficient of correlation of the four populations of *C. carinatus* are given in Table 3.

A total number of 127 individuals of *C. carinatus* were examined. The sample size ranged from 8 from Manavgat river estuary to 96 from Seyhan river estuary. The size structures of the four populations were different in the estuaries. The lengths ranged from 14.0-18.5 cm in Manavgat river estuary, 14.3-19.2 cm in Göksu river estuary, 14.0-19.5 cm in Ceyhan river estuary, and 11.8-20.8 cm in Seyhan river estuary; while the weights were between 34-89, 36-93, 32.8-91.6, and 19-113.6 g in Manavgat, Göksu, Ceyhan, and Seyhan river estuary, respectively. The total length in all individuals (from all populations) ranged between 11.8 and 20.8 cm with mean value of 17.7 cm; while the weight ranged

between 19.0 and 113.6 g with mean value of 71.2 g were recorded.

The calculated values for b in length and weight relationship ranged from 3.14 to 3.32. The length-weight relationship for all individuals (from all populations) was described by the following parameters: $a = 0.0076$ and $b = 3.1708$. Based on the t -test, the growth exponents, b of *C. carinatus* were significantly different ($p < 0.05$) from 3 (Table 3). *C. carinatus* has an positive allometric growth type in all the populations. Length frequency significantly changed depending on seasons. The coefficients of determination values r^2 of the total length-weight relationship are 0.92, 0.98, 0.92, 0.93 for Manavgat, Göksu, Seyhan and Ceyhan river estuaries, respectively, reflecting a good correlation between the length and weight parameters.

Discussion

Numerous species have expanded their distribution ranges as a result of lesepsian migrations and/or human activities. The alien species of the family Mugilidae in the coasts of Turkey include the lessepsian keeled mullet *Chelon carinatus* and the introduced redlip mullet *Planiliza haematocheila*¹⁵.

Keeled mullet occurs mainly in coastal waters and coral reefs and is also found in inland waters and estuaries of rivers¹³. *C. carinatus* has been firstly recorded in the Mediterranean Sea in Egypt¹⁶. The occurrence of *C. carinatus* in estuarine systems of Mediterranean is not well known. After its migration to Mediterranean, the only estuarine system where *C. carinatus* has been reported in Turkey is Köyceğiz Lagoon estuary system¹⁷. This is the first study to describe its occurrence in Ceyhan, Seyhan, Göksu and Manavgat river estuaries of the Mediterranean coast of Turkey.

Estuaries are important fish habitats since they provide nursery grounds for a variety of fish species¹⁸. It has been well documented that juveniles of

Table 3 — Summary of length-weight relationships for *C. carinatus*

Locality (River estuary)	N	TL (cm)	W (g)	a	b	r^2
		Range (Min-Max)	Range (Min-Max)			
Manavgat	8	14.0-18.5	34-89	0.0048	3.3204	0.9229
Göksu	9	14.3-19.2	36-93	0.0061	3.2677	0.9845
Ceyhan	14	14.0-19.5	32.8-91.6	0.0054	3.2936	0.9238
Seyhan	96	11.8-20.8	19-113.6	0.0082	3.1419	0.9257
All individuals	127	11.8-20.8	19-113.6	0.0076	3.1708	0.9312

numerous fish species are found in relatively high abundance in brackishwater systems^{19,20}. Various human activities have potentially detrimental effects on estuarine fish stocks and their habitats²¹. The studied estuarine systems showed a high range of variability in species composition. All studied rivers are highly diverse ecosystems and support extensive fish diversity. In these river basin, there are many endemic species with very limited ranges.

The fish fauna of studied estuarine systems was dominated by mugilid species. Dominancy of mugilids in estuarine systems had been also reported earlier in the estuarine systems of Turkey^{17,22,23}. During the study period, individuals of *C. carinatus* were caught in all estuarine systems with small numbers compared to other Mugilids. Like other mugilid species, *C. carinatus* has the capability of tolerating a wide range of salinity²⁴. The occurrence of this species in studied estuarine systems is greatly facilitated by its high temperature and salinity tolerance. This situation would cause colonization by *C. carinatus* of different brackish water habitats in the Mediterranean Sea. Keeled mullet passes into lagoons and estuaries with thick vegetation in spring, and deep coastal waters in winter. Spawning occurs between August and October²⁵. It is understood from this study results that *C. carinatus* occupy studied estuarine systems in summer, compared to other seasons.

Keeled mullet was caught from four river systems in different numbers using the same standard sampling technique. This situation is thought to be caused by different environmental characteristics of estuarine systems (Table 2). Distribution and occurrence of fish depends on many environmental parameters, such as water temperature, water depth, dissolved oxygen and other physico-chemical parameters, and biotic factors, such as macrophytes, predators and food resources.

There are few studies that have focused on the biology of *C. carinatus* in Mediterranean Sea. The present report represent the first approach to LWRs of keeled mullet in four Mediterranean river estuaries. The estimated parameter *b* showed positive allometric growth for all populations. These data are supported by high values of correlation indicating an elevated predictability between total length and weight of the studied populations. Positive allometric growth was also observed from Bitter Lakes ($b = 3.0479$), Egypt²⁶. Contrary to the present study results negative allometric growth was reported in several previous studies in length-weight relationship parameters for

Chelon carinatus and the reported *b* value were 2.5897 in Suez Bay²⁷; 2.864 in Mediterranean Sea²⁸; 2.205 in Northern Arabian Sea²⁹; and 2.869 in Suez Bay³⁰. Differences in slopes might be a result of differences among the number and length range of specimens examined as well as the effect of area or season³¹.

This study provides some important information for understanding the biology of keeled mullet from an estuary ecosystems. Future research will focus on the role of *Chelon carinatus* in the estuarine ecosystems and its effects on local populations.

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Conflict of Interest

Author declares no conflict of intrests.

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