

# Diversity and Length-Weight relationships of Blenniid Species (Actinopterygii, Blenniidae) from Mediterranean Brackish Waters in Turkey

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## ABSTRACT

This study aims to determine the species composition and range of Mediterranean Blennies (Actinopterygii, Blenniidae) occurring in river estuaries and lagoon systems of the Mediterranean coast of Turkey, and to characterise the length–weight relationship of the specimens. A total of 15 sites were surveyed from November 2014 to June 2017. A total of 210 individuals representing 3 fish species (Rusty blenny-*Parablennius sanguinolentus*, Freshwater blenny-*Salaria fluviatilis* and Peacock blenny-*Salaria pavo*) were sampled from five (Beşgöz Creek Estuary, Manavgat River Estuary, Karpuzçay Creek Estuary, Köyceğiz Lagoon Lake and Beymelek Lagoon Lake) of the localities investigated. The high juvenile densities of *S. fluviatilis* in Karpuzçay Creek Estuary and *P. sanguinolentus* in Beşgöz Creek Estuary were observed.

Various threat factors were observed in five different native habitats of Blenny species. The threats on the habitat and the population of the species include the introduction of exotic species, water pollution, and more importantly, the destruction of habitats. Five non-indigenous species (Prussian carp-*Carassius gibelio*, Eastern mosquitofish-*Gambusia holbrooki*, Redbelly tilapia-*Coptodon zillii*, Stone moroko-*Pseudorasbora parva* and Rainbow trout-*Oncorhynchus mykiss*) were observed in the sampling sites. In addition to these freshwater species, several lessepsian species (Keeled mullet-*Liza carinata*, Por's goatfish-*Upeneus pori*, Goldband goatfish-*Upeneus moluccensis*, Marbled spinefoot-*Siganus rivulatus*, *Sillago suezensis* and Yellowstripe barracuda-*Sphyrna chrysotaenia*) were observed in the sampling areas.

**Keywords:** Peacock blenny, Freshwater blenny, Rusty blenny, distribution, estuary

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## INTRODUCTION

Blenniidae are one of the most abundant fish families inhabiting tropical and subtropical regions. The family consists of 58 genera and 397 species (Nelson, Grande, & Wilson, 2016). The blennids of the Mediterranean display a remarkable diversity with regard to habitat preferences, feeding habits, and behaviour (Patzner, Gonçalves, & Hastings, 2009).

Twenty species have been reported in the Eastern Mediterranean with 3 alien species includ-

ed. Alien Blenny species were introduced to the Mediterranean-Black Sea Basin from the Suez Canal (Golani, Öztürk, & Başusta, 2006). As there is a low interest of commercial fishing of this family in the Turkish coast, there is no available data on the catch statistics of this species.

The biological data on the species, however, are scarce and limited to their distribution (Erzi, 1941; Steinitz, 1950; Aksiray, 1987; Çoker, 1996; Taşkavak, Bilecenoglu, Basusta, & Mater 2000; Bat, Gönlügür Demirci, & Öztürk 2006; Yılmaz, Barlas, Yorulmaz, & Özdemir 2006; Bi-

Iecenoğlu, Kaya, Cihangir, & Çiçek, 2014; Özgür-Özbek, Özkaya, Öztürk, & Golani, 2014), parasitology (Alaş, Öktener, Iscimen, & Trilles 2008; Özer, Özkan, Gürkanlı, Yurakhno, & Çiftçi, 2016) and evolution (Zander, 1972; Almada et al., 2009).

The parameters of the length-weight relationship (LWR) of the fish species are crucial in the fisheries' biology, supplying the information on several aspects of fish population dynamics (Bagenal & Tesch, 1978). The current knowledge on LWRs for Blennies is limited to six species, namely, *Aidablennius sphyinx* (Özen, Ayyıldız, Öztekin, & Altın 2009), *Blennius ocellaris* (Çiçek, Avsar, Yeldan, & Ozutok, 2006; Sangun, Akamca, & Akar, 2007; Özaydın, Uçkun, Akalın, Leblebici, & Tosunoğlu, 2007; İşmen, Özen, Altınağaç, Özekinci, & Ayaz, 2007; İlkyaz, Metin, Soykan, & Kınacıgil 2008; Bok et al., 2011; Acarlı, Kara, & Bayhan 2014; Bilge, Yapıcı, Filiz, & Cerim, 2014), *Salaria pavo* (Özen et al., 2009; Bilge et al., 2014), *Parablennius sanguinolentus* (Keskin & Gaygusuz, 2010; Kara, Sağlam, Acarlı, & Cengiz, 2017), *Parablennius tentacularis* (Keskin & Gaygusuz, 2010), *Salaria fluviatilis* (İlhan, Ustaoglu, & Berberoğlu 2013; Ergüden, 2016; Kara et al., 2017).

In both temperate and tropical habitats, the coastal lagoons and estuaries play a crucial role in the aspect of ecology and biology of the species (Bruno, Barbini, Diaz De Astarloa, Martos, & 2013). Status of Blennies fish composition in Brackishwater systems are still poorly understood. The current study aims to update the range and species composition of Blennids occurring in river estuaries and lagoon systems of Mediterranean coast of Turkey, and to characterise the length-weight relationship of specimens.

## MATERIALS AND METHODS

A total of 15 sites (Yelkoma Lagoon Lake, Ceyhan River Estuary, Seyhan River Estuary, Göksu River Estuary, Paradeniz Lagoon Lake, Berdan River Estuary, Sultansuyu Creek Estuary, Hacimusa Creek Estuary, Karpuzçay Creek Estuary, Manavgat River Estuary, Köprüçay River Estuary, Beşgöz Creek Estuary, Kopak Creek Estuary, Beymelek Lagoon Lake and Köyceğiz Lagoon Lake), representing a variety of habitats (including mouths of rivers and creeks, coastal canals of rivers and lagoonal areas), were repeatedly surveyed from November 2014 to June 2017. Details (Type, substrate structure, macrophyte vegetation density, flow regime) of habitats were recorded. Sampling localities are given in the map (Figure 1), and sampling sites and descriptions are given in Table 1 and Table 2.

The ichthyofauna of the systems was sampled using a shore seine net (10 m long and 2 m high; 1.2 x 2 mm mesh size). Fish species were identified according to Aksiray (1987). The introduced and exotic taxa of the species were identified following İnal & Erk'akan (2006). At each locality, the general observations on the population and its situation were also made. Specimens were weighed to the nearest 0.01 g total weight (W) and were measured to the nearest 0.1 cm in total length (TL). The a and b parameters were calculated by linear regression on the transformed equation:  $\log(w) = \log(a) + b \log(L)$ . For each species, the slopes of length-weight regressions were compared to 3 using student's t-test.



**Figure 1.** 1-Köyceğiz Lagoon Lake; 2- Beymelek Lagoon Lake; 3- Kopak Creek Estuary; 4- Beşgöz Creek Estuary; 5- Köprüçay River Estuary; 6- Manavgat River Estuary; 7- Karpuzçay Creek Estuary; 8- Hacimusa Creek Estuary; 9- Sultansuyu Creek Estuary; 10- Paradeniz Lagoon Lake; 11- Göksu River Estuary; 12- Berdan River Estuary; 13- Seyhan River Estuary; 14- Ceyhan River Estuary; 15- Yelkoma Lagoon Lake.

**Table 1.** Sampling sites with its coordinates

No	Locality	Coordinates	
1	Köyceğiz, Köyceğiz (Muğla)	36°57'30.45"N	28°40'30.46"E
2	Beymelek, Demre (Antalya)	36°16'26.25"N	30° 3'15.01 "E
3	Kopak, Aksu (Antalya)	36°51'7.27 "N	30°52'1.87 "E
4	Beşgöz, Serik (Antalya)	36°51'21.89"N	30°56'39.81"E
5	Köprüçay, Serik (Antalya)	36°49'46.82"N	31°10'26.82"E
6	Manavgat, Manavgat (Antalya)	36°44'18.42"N	31°29'38.43"E
7	Karpuzçay, Manavgat (Antalya)	36°42'56.84"N	31°33'00.95"E
8	Hacımus, Gazipaşa (Antalya)	36°15'45.14"N	32°16'46.54"E
9	Sultansuyu, Anamur (Mersin)	36° 2'15.42"N	32°49'8.11 "E
10	Paradeniz, Silifke (Mersin)	36°18'27.51"N	34° 0'39.00"E
11	Göksu, Silifke (Mersin)	36°17'46.24"N	34° 2'42.75"E
12	Berdan, Tarsus (Mersin)	36°44'53.83"N	34°53'29.27"E
13	Seyhan, Tarsus (Mersin)	36°43'44.41"N	34°54'37.71"E
14	Ceyhan, Karataş (Adana)	36°34'10.83"N	35°33'36.15"E
15	Yelkoma, Yumurtalık (Adana)	36°42'27.30"N	35°40'36.72"E

**Table 2.** Habitat description of sampling sites

Locality	Type	Substrates	Macrophyte vegetation	Flow velocity
Köyceğiz, Köyceğiz (Muğla)	Coastal lake	gravel-silt-sand	Medium	Steady
Beymelek, Demre (Antalya)	Coastal lake	silt-sand	Low	Steady
Kopak, Aksu (Antalya)	Open creek estuary	silt-sand	Low	Slow
Beşgöz, Serik (Antalya)	Open creek estuary	silt-sand	Medium	Slow
Köprüçay, Serik (Antalya)	Open river estuary	gravel-silt-sand	Low	Fast
Manavgat, Manavgat (Antalya)	Open river estuary	silt-sand	Low	Fast
Karpuzçay, Manavgat (Antalya)	Closed creek estuary	silt-sand	Low	Slow
Hacımus, Gazipaşa (Antalya)	Open creek estuary	gravel-silt-sand	Low	Slow
Sultansuyu, Anamur (Mersin)	Open creek estuary	gravel-silt-sand	Low	Slow
Paradeniz, Silifke (Mersin)	Coastal lake	silt-sand	Low	Steady
Göksu, Silifke (Mersin)	Open river estuary	silt-sand	Low	Fast
Berdan, Tarsus (Mersin)	Open river estuary	silt-sand	Low	Slow
Seyhan, Tarsus (Mersin)	Open river estuary	silt-sand	Medium	Fast
Ceyhan, Karataş (Adana)	Open river estuary	silt-sand	Medium	Fast
Yelkoma, Yumurtalık (Adana)	Coastal lake	silt-sand	Low	Steady

## RESULTS AND DISCUSSION

Brackishwater systems of the Mediterranean encompass diverse habitat types and provide nursery grounds for a number of Blenniid species. A total of 210 individuals representing 3 fish species [*Parablennius sanguinolentus* (Pallas, 1814), *Salaria fluviatilis* (Asso, 1801) and *Salaria pavo* (Risso, 1810)] were sampled from five (Beşgöz Creek Estuary, Manavgat River Estuary, Karpuzçay Creek Estuary, Köyceğiz Lagoon Lake and Beymelek Lagoon Lake) of the localities investigated.

One hundred and seven individuals of *P. sanguinolentus* were found at Beşgöz Creek and Manavgat River Estuary, 100 individuals of *S. fluviatilis* were found at three localities (Karpuzçay

Creek Estuary, Manavgat River Estuary and Köyceğiz Lagoon Lake), 3 individuals of *S. pavo* were found in one locality (Beymelek Lagoon Lake). As can be seen in Table 3, the sample size ranged from 3 individuals for *S. pavo* to 87 for *P. sanguinolentus*.

The high juvenile densities recorded for *S. fluviatilis* in Karpuzçay Creek Estuary and *P. sanguinolentus* in Beşgöz Creek Estuary suggest that Beşgöz and Karpuzçay Estuaries provide an important nursery grounds for these species. Nursery areas may be attractive to Blenny species because they provide high food availability and low predation pressure (Martinho et al., 2007; Francis, 2013). Several factors may affect the distribution of Blenny species at the examined stations such as life history, hydrological conditions, predation, prey availability, and anthropogenic impacts.

**Table 3.** Locality, sample size and size range (cm, TL; g, W) of species

Species	Locality	N	TL (Min-Max)	W (Min-Max)
<i>S. pavo</i>	Beymelek	3	8.6-9.2	4.0-5.9
	Karpuzçay	74	2.5-7.5	0.15-4.94
<i>S. fluviatilis</i>	Köyceğiz	15	2.8-5	0.15-0.85
	Manavgat	11	2.1-5	0.075-0.99
	All populations	100	2.1-7.5	0.075-4.94
<i>P. sanguinolentus</i>	Beşgöz	87	2.1-4.2	0.072-0.83
	Manavgat	20	1.7-5.0	0.032-0.85
	All populations	107	1.7-5.0	0.032-0.85

**Table 4.** Length-weight parameters a and b values of species (Growth pattern; N: negative allometry; P: positive allometry; I: Isometry)

Species	Locality	a	b	95% CI of b	t-test	Growth pattern	R <sup>2</sup>
<i>S. pavo</i>	Beymelek						
<i>S. fluviatilis</i>	Karpuzçay	0.0095	3.077	3.0629-3.0943	p<0.05	P	0.99
	Köyceğiz	0.0082	2.869	2.8232-2.9133	p<0.05	N	0.97
	Manavgat	0.0074	2.963	2.8996-3.0323	p=0.279	I	0.99
<i>P. sanguinolentus</i>	All populations	0.0062	3.308	3.2755-3.3339	p<0.05	P	0.96
	Beşgöz	0.0047	3.655	3.629-3.6728	p<0.05	P	0.96
	Manavgat	0.0069	3.0078	2.9347-3.058	p=0.903	I	0.99
	All populations	0.006	3.367	3.3379-3.3942	p<0.05	P	0.95

Very little information is available on the ecology of most of the Blenny species, which do not have commercial fishery value. Length-weight parameters a, b and the correlation coefficient values are given in Table 4.

The total length of 2.1- 7.5 cm with the mean value of 4.34 cm for *S. fluviatilis*, the total length of 8.6- 9.2 cm with the mean value of 8.93 cm for *S. pavo* and the total length of 1.7- 5.0 cm with the mean value of 2.82 cm for *P. sanguinolentus* were recorded. Also, the weight of 0.075- 4.94 g with the mean value of 1.07 g, 4.0 -5.9 g with the mean value of 4.67 g and 0.032 -0.85 g with the mean value of 0.23 g for *S. fluviatilis*, *S. pavo* and *P. sanguinolentus* were recorded, respectively. *Salaria pavo* was however, excluded because of the inadequate sample size.

The slope b value of the length-weight relationships for *S. fluviatilis* from all localities was 3.308 (100 individuals). The slope b value of the length-weight relationships for *P. sanguinolentus* investigating all localities was 3.367 (107 individuals). The correlation coefficient values ranged from 0.95-0.99. The values of parameter b for the localities evaluated was found to be within the expected range of 2.5-3.5 as described by Froese (2006), with Beşgöz as an exception. The parameter b value for Beşgöz was found to be 3.638. The maximum length of *Parablennius sanguinolentus* found in the current study was smaller than other studies (Keskin & Gaygusuz, 2010; Liouisia et al., 2012). Outside of b value from its normal range (2.5-3.5) could be due to the small length range (2.1-4.2 cm) of *P. sanguinolentus*, the data were not representative for big size individuals. Manavgat population of *P.*

*sanguinolentus* has an isometric growth type while Beşgöz population has a positive allometric growth type.

Among the populations of *S. fluviatilis* analyzed, one population (Manavgat River Estuary) showed isometry, two populations (Karpuzçay Creek Estuary and Köyceğiz Lagoon Lake) showed allometry. Of the "b" value for seven populations of *S. fluviatilis* reported by İlhan et al., 2013, among the population analyzed, one population (Doğu Akdeniz) showed negative allometry, five populations (Marmara, Küçük Menderes, Antalya, Seyhan and Ceyhan populations) showed Isometry and one population (Batı Akdeniz) showed positive allometry. Variations of growth types reported by the current study and previous reports may be due to physico-chemical and biological parameters of systems and studied methods (time, sampling equipments, length range, gonadal maturity, sex, preserved techniques).

Although *S. fluviatilis* in Turkey shows a large distribution in aquatic systems such as coastal lagoons, estuaries and freshwater systems, *P. sanguinolentus* and *S. pavo* are restricted to only marine habitats. However, there has not been sufficient data about threats to the latter two species in previous studies. Threat status of these species are of the least concern (Di Natale et al., 2014 a, b).

*S. fluviatilis* was reported from drainage of the Aeagean, Black Sea and Mediterranean regions of Turkey (Geldiay & Balık, 1996; Demirsoy, 2002; Bostancı, Darçın, & Helli, 2016). However, *S. fluviatilis* was commonly reported in sea level habitats. Alp & Kara

**Table 5.** Alien fish species of localities

No	Species	Family	Köyceğiz	Beymelek	Beşgöz	Manavgat	Karpuzçay
<b>Native Blenny species</b>							
1	<i>Salaria pavo</i>	Blenniidae		√			
2	<i>Salaria fluviatilis</i>	Blenniidae	√			√	√
3	<i>Parablennius sanguinolentus</i>	Blenniidae			√	√	
<b>Alien species</b>							
1	<i>Coptodon zillii</i>	Cichlidae	√				
2	<i>Carassius gibelio</i>	Cyprinidae			√	√	
3	<i>Pseudorasbora parva</i>	Cyprinidae			√	√	
4	<i>Liza carinata</i>	Mugilidae			√	√	
5	<i>Upeneus moluccensis</i>	Mullidae				√	
6	<i>Upeneus pori</i>	Mullidae				√	
7	<i>Gambusia holbrooki</i>	Poeciliidae	√	√	√	√	√
8	<i>Oncorhynchus mykiss</i>	Salmonidae				√	
9	<i>Siganus rivulatus</i>	Siganidae		√	√	√	
10	<i>Sillago suezensis</i>	Sillaginidae			√	√	
11	<i>Sphyaena chrysotaenia</i>	Sphyaenidae				√	

(2007) reported that this species is present in Turkey from high mountain creeks up to 750 meters. *S. fluviatilis* is found in Mediterranean freshwater systems with small and localized populations (Vinyoles, Cote, & De Sostoa, 2002). In Mediterranean habitats in which *S. fluviatilis* occurs, the water pollution, eutrophication, deterioration of the quality of the water, gravel extraction, loss of habitat, the existence of exotic species, and construction of dams and river channelization have affected the survival of this species (Crivelli, 2006; Vinyoles, De Sostoa, Casals, & Bianco 1991; Ferrito & Tigano, 1996; Vinyoles & De sostoa, 2007; Laportea, Bertolo, Berrebi, & Magnan, 2014).

Five brackishwater systems throughout the Turkish coast have been classified as nurseries for three Blennid fish species (*S. fluviatilis*, *P. sanguinolentus* and *S. pavo*). The results of this study indicate that Blenny species are threatened and under significant danger from many anthropogenic activities.

Eleven fish species from nine families were identified as being alien to the 5 brackishwater systems surveyed in this study (Table 5). Ten non indigenous species (*Gambusia holbrooki*, *Liza carinata*, *Upeneus pori*, *Siganus rivulatus*, *Sillago suezensis*, *Oncorhynchus mykiss*, *Sphyaena chrysotaenia*, *Carassius gibelio*, *Upeneus moluccensis* and *Pseudorasbora parva*) were observed in the same habitat with *Parablennius sanguinolentus* and *Salaria fluviatilis* in Manavgat River Estuary in the current study.

*S. fluviatilis* was also observed in Köyceğiz lagoon and Karpuzçay Creek, both of which have been subjected to agricultural activity. *Coptodon zillii* and *Gambusia holbrooki* in Köyceğiz Lagoon and *Gambusia holbrooki* in Karpuzçay Creek shared the same habitats with *S. fluviatilis*.

Six non indigenous species (*Carassius gibelio*, *Pseudorasbora parva*, *Liza carinata*, *Gambusia holbrooki*, *Siganus rivulatus* and *Silla-*

*go suezensis*) were observed in the same habitat with *Parablennius sanguinolentus* in Beşgöz Creek Estuary in the current study.

Furthermore, the freshwater supply of Beşgöz Creek and Karpuzçay Creek had greatly decreased in recent years due to agricultural irrigation. Municipal waste waters have been discharged into Beşgöz Creek, Köyceğiz Lagoon and Manavgat River.

## CONCLUSIONS

*P. sanguinolentus*, *S. pavo* and *S. fluviatilis* were collected in five brackishwater systems in the Mediterranean Coast of Turkey (Beşgöz Creek Estuary, Manavgat River Estuary, Karpuzçay Creek Estuary, Köyceğiz Lagoon Lake and Beymelek Lagoon Lake). The high juvenile densities recorded for *S. fluviatilis* in Karpuzçay Creek Estuary and *P. sanguinolentus* in Beşgöz Creek Estuary suggest that Beşgöz and Karpuzçay Estuaries provide an important nursery grounds for these species. Various threat factors were observed in five different localities which are the habitat of Blennid species.

The current study supplies some fundamental information about the distribution and Length-weight relationships of brackishwater Blenny species and can be helpful for the future studies in the region.

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**Ethics Committee Approval:** This study was carried out in accordance with animal welfare and the ethics of trial. All procedures were performed in accordance with the Law on Veterinary and Medical Activities and National Animal Welfare Act. Therefore ethics approval was not required.

**Conflict of Interests:** The author declares that there are no conflicts of interest.

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