Research Article

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Age Structure and Length-Weight Relationship of Non-native Redbelly Tilapia *Coptodon zillii* (Gervais, 1848) (Cichlidae) in the Pınarbaşı Spring Creek (Burdur, Turkey)

Deniz Innal[1]* & Daniela Giannetto[2]

[1] Department of Biology, Mehmet Akif Ersoy University, Istiklal Campus, 15100 Burdur, Turkey; E-mail: innald@gmail.com
[2] Department of Biology, Faculty of Science, Muğla Sıtkı Koçman University, 48000 Kötekli, Muğla, Turkey

Abstract: The redbelly tilapia, *Coptodon zillii,* is found in more than 56 countries as a native or introduced fish. In Turkey it is a non-native species and it is present with several acclimatised populations. A population of *C. zillii,* which almost certainly originated from aquarium industry ponds located in the area of Burdur, is well-established in the Pınarbaşı Spring Creek (Burdur, Turkey). This paper aims to study the population structure and some growth properties of *C. zillii* living in Pınarbaşı Spring Creek. For this purpose, age and sex composition and length-weight relationships were examined and then compared with those reported for other populations. During the study period (from November 2013 to June 2016), a total of six fish species (*C. zillii*, *Oreochromis niloticus*. *Oxynoemacheilus anatolicus*, *Gambusia holbrooki*, *Carassius gibelio, Clarias* sp.) were caught by electrofishing. Among all, *C. zillii* has the highest abundance (54.77%). Totally, 155 specimens of *C. zillii*, ranging in size from 2.4 to 20.5 cm in total length and from 0.16 to 166.1 g in total weight, were collected. Of all the examined *C. zillii,* 80 specimens were immature, 44 were female and 31 were male. The overall sex ratio of females to males was 0.7:1. Ages of captured specimens ranged from 0 to IV. The length-weight relationship for all individuals was described by the parameters a = 0.0078 and b = 3.3543.

Key words*:* Alien fish, sex ratio, growth, Pınarbaşı Spring Creek, Turkey

Introduction

Alien species are known to strongly impact native community causing significant losses of biodiversity and altering the functioning of ecosystems (Mack et al. 2000, Byers et al. 2002). With regard to aquatic ecosystems, the introduction of alien fish is recognised as one of the greatest threats to biodiversity and to the integrity of native communities (Helfman 2007). Within aquatic ecosystems, freshwaters are more sensitive to non-native species introductions because of their isolation (Stiassny 1991, Dudgeon et al. 2006).

In the last two centuries, a wide number of non-native fish species have been introduced into freshwater systems mainly for recreational purposes, aquaculture and ornament (Welcomme 1988). The tilapiine fishes are species of the family Cichlidae all native to Africa (Trewavas 1983) but since the 1950s, they have been largely exported throughout the world both for biocontrol of aquatic weeds and insects and for aquaculture (Crutchfield 1995, Courtenay 1997, Costa-Pierce 2003).

The redbelly tilapia, *Coptodon zillii* (Gervais, 1848), is native to tropical and subtropical Africa and south-west Asia (Froese & Pauly 2016), but as other tilapia species, it has been introduced globally mainly for aquaculture purposes and for consumption (Chakrabarty 2004). Until recently the species was formerly known as *Tilapia zillii*, but

*Corresponding author

the name has been recently changed to *Coptodon zillii* following a molecular phylogenetic study by Dunz & Schliewen (2013). *C. zillii* generally prefers shallow, vegetated areas in tropical climate, however, being highly euryhaline the species is able to survive in habitats of a wide salinity range, such as estuaries and even shallow marine habitats (Fishelson & Bresler 2002) and it has been occasionally reported from marine waters (Costa-Pierce 2003, Froese & Pauly 2016). *C. zillii* can also tolerate different range of pH (from 6 to 9) and temperatures from 11°C to 36°C (with an optimum between 20°C and 32°C; Briggs 1984). This high adaptability is considered the key reason for the wide geographic distribution of the species (Stiassny 1991), which is currently found in more than 56 countries, in most of them non-native (Froese & Pauly 2016). *C. zillii* is an omnivorous species capable to alter significantly native benthic communities through the elimination of macrophytes and outcompeting both native and non-native species for food, habitat and spawning sites through aggressive interactions (Spataru 1978, GISD 2017). For all these reasons, the species is listed as a potential pest (Froese & Pauly 2016). *C. zillii* was first introduced in Turkey in the 1970s for aquaculture as part of government authorised research programmes (Dikel 1995, Innal & Erk'akan 2006, Tarkan et al. 2015). This species was selected because it is among the most resistant fishes against diseases and cultured conditions, such as high stocking density, organic pollution and low dissolved oxygen in the water (Altun et al. 2006). Currently the species is reported from several environments with viable populations (Dikel & Çelik 1998, Gökçe et al. 2003, Çelik & Gökçe 2003, Akin et al. 2005) mainly generated by escaped individuals from the aquaculture cages (Innal 2012). Although the species has been largely studied within the native range (Botros 1968, El-Zarka et al. 1970, Khallaf & El-Nenaei 1987, Latif et al. 1989, Faltas 1995, Basu & Kalu 1999, El-Kashef 2002, Hadi 2008), very little is known about the introduced populations. To the best of our knowledge, up to date there are no available data on age and growth of *C. zillii* populations in Turkey.

The aim of this study was to investigate the population structure and length-weight relationships in the population of *C. zillii* living in the Pınarbaşı Spring Creek, Burdur, Turkey.

Materials and Methods

The study was carried out in the Pınarbaşı Spring Creek (Pınarbaşı Village, N 37°27'09.78"; E 30°03'29.44›› – N 37°27'13.77"; E 30°03'03.56››) in the Burdur Province within the Lake District Region in south-western Anatolia (Turkey). The study area is a specific closed basin: waters from the Pınarbaşı Spring Creek flow into Karaçal Dam Lake through the Bozçay Creek. Then, from the dam lake, waters reach Burdur Lake. The hydrogeological and hydrogeochemical composition of the environment is particular, comprising Ca- and Mg-HCO_3 (Varol & Davraz 2010). The Pınarbaşı Springs have been generated from an overthrust zone developed between Kızılcadağ ophiolite and Dutdere limestone and the environment is characterised by warm waters generated probably by the high geothermal gradient resulting from the tectonic regime. Furthemore, the natural isotope content of the waters suggests their meteoric origin (Varol & Davraz 2010). The study area hosts several aquarium industry ponds located throughout the province of Burdur.

Fish samplings were carried out in the Pınarbaşı Springs Creek from November 2013 to June 2016 by means of electrofishing. After collection, the abundance of each species caught was estimated.

Water quality parameters were measured at the surface at the start of each field trip. Temperature (°C), salinity, pH and dissolved oxygen concentration were determined by using a YSI water meter (Professional Plus). The specimens of *C. zillii* were measured for total (TL), standard (SL), and fork (FL) lengths to the nearest millimetre, and weighted (W in g) with a digital balance with an accuracy of 0.1 g. A sample of scales was removed from each specimen for age determination. In the laboratory, the samples of scales were firstly cleaned with distilled water and 8% NaOH, and after dried, were mounted on microscope cover-slips for subsequent readings. The sex of the specimens was recognised by means of macroscopic analysis of gonads. Differences in the sex ratio were estimated by X^2 test. The overall population structure was assessed by breaking down the sample in 2-cm TL classes. Specific FL-TL and SL-TL relationships were assessed, using the following linear regressions:

$$TL = a + b\ SL$$

and

$$TL = a + b\ FL$$

Where 'a' is the intercept on Y-axis, and 'b' is the regression coefficient.

Length-weight relationships were estimated for the total sample and separated by sex, according to the equations suggested by Ricker (1975):

$$W = a\ TL^b$$

Results

During the study period, a total of six fish species were caught in the Pınarbaşı Springs Creek: *C. zillii* (54.77%), *Oreochromis niloticus* (4.24%), *Oxynoemacheilus anatolicus* (3.53%), *Gambusia holbrooki* (28.27%), *Carassius gibelio* (8.83%) and *Clarias* sp. (0.35%). Only *O. anatolicus* was a native species to the area, whereas all the others were non-native fish with *C. zillii* being the most abundant followed by *G. holbrooki*.

The water temperature ranged from 25°C to 29.4°C, salinity – from 0.21 to 0.24 ‰, pH – from 7.7 to 8.4, and dissolved oxygen concentration – from 4.5 to 6.2 mg/l.

The examined sample of *C. zillii* was composed of 155 specimens, ranging in size between 2.4 and 20.5 cm and in weight between 0.16 and 166.1 g, with the highest percentage of specimens in 5-8 cm length class and 0-20 g weight class.

A total of five age classes ranging from 0 to IV were estimated (Table 1). Totally, 80 juveniles, 44 females and 31 males were identified (Fig. 1).

The overall F:M sex ratio was 0.7:1 and it was not statistically different from 1:1 ($X^2 = 2.253$; $p > 0.05$).

The specific SL-TL and FL-TL relationships, calculated for a subsample of 35 specimens, resulted in:

$TL = 0.2965 + 1.2131\ SL$ ($R^2 = 0.994$)

and

$TL = -0.0203 + 1.0178\ FL$ ($R^2 = 0.999$).

The length-weight relationship for the total sample was calculated as:

$W = 0.0078\ TL^{3.3543}$ ($R^2 = 0.993$).

For females:

$W = 0.0149\ TL^{3.0852}$ ($R^2 = 0.983$).

For males:

$W = 0.0179\ TL^{3.0163}$ ($R^2 = 0.989$).

Discussion

Coptodon zillii is considered suitable for aquaculture thanks to its high tolerance to environmental variability, high fecundity (Duponchelle et al. 1998), rapid growth rates (El-Sayed 1999, Liti et al. 2005), and omnivorous feeding (Mair 2001). These are also the key features that consent to a non-native species to proliferate easily in areas outside its native range (Costa-Pierce 2003, Peterson et al. 2006). Knowledge of basic biology and life-history traits is one of the crucial steps for the management of alien species in freshwater ecosystems (Louette & Declerk 2006). Previous studies on *C. zillii* outside its native range focused exclusively on growth performance of fish stock cultured in ponds for aquaculture purposes (Krom et al. 1985, Bruton & Gophen 1992, Mahomoud et al. 2011, Nehemia et al. 2012). To date, too little is known about non-native acclimatised populations of *C. zillii* and only a few case studies reported detailed information

Table 1. Age composition of the redbelly tilapia, *Coptodon zillii*, from the Pınarbaşı Spring Creek. TL – total length; W –weight; SD – standard deviation

TL (cm)	Age groups (in years)					Total
	0	I	II	III	IV	
2.0-3.9	22					22
4.0-5.9	40	2				42
6.0-7.9		16				16
8.0-9.9		19				19
10.0-11.9		8	16			24
12.0-13.9			15	1		16
14.0-15.9				10		10
16.0-17.9				3		3
18.0-19.9					1	1
20.0-21.9					2	2
Total	62	45	31	14	3	155
Range TL	2.4-5.9	5.9-10.7	10.5-13.7	13.5-17.0	19.3-20.5	2.4-20.5
Mean TL±SD	4.55±0.97	8.36±1.52	11.84±0.96	15.25±0.96	19.97±0.54	8.38±4.06
Range W	0.16-3.14	3.16-22.38	18.99-47.84	44.99-84.61	135.00-166.10	0.16-166.10
Mean W±SD	1.52±1.01	11.62±6.24	31.45±8.59	66.88±12.36	147.03±14.55	19.16±27.21

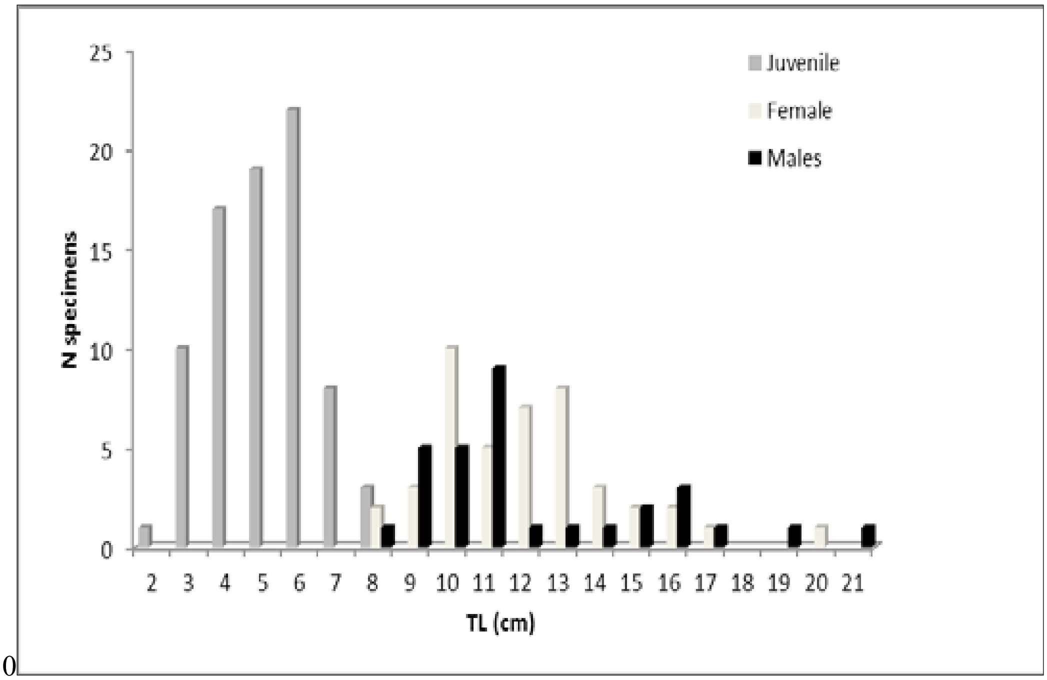

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Fig. 1. Total length composition for juveniles, females and males of the redbelly tilapia, *Coptodon zillii*, from the Pınarbaşı Spring Creek. a – intercept; b –regression coefficient; R^2 – correlation coefficient; N – number of specimens; F – females; M – males; TL – total length; SL – standard length; and FL – fork length

Table 2. Estimated parameters of length-weight regressions for different native populations of the redbelly tilapia, *Coptodon zillii*, and the non-native population from the Pınarbaşı Spring Creek

a	b	Sex	Length range (cm)	Length type	R^2	N	Country	Locality	References
0.0218	2.972	–	4.0-28.0	TL	0.987	268	Benin	Ouémé River Basin	Lalèyè (2006)
0.0441	2.743	–		TL	0.941	90	Burkina Faso	Hippopotamus Pond	Béares (2003)
0.0751	2.81	–	10.0-27.0	SL	0.984	17	Burkina Faso	Volta River	Coulibaly (2003)
0.017	2.837	–	5.5-24.5	SL	0.947	208	Cote d'Ivoire	River Bia; Rivers Soumié, Eholié, Ehania and Noé	Konan et al. (2007)
0.0136	3.156	–	3.7-21.0	FL	0.960	262	Kenya	Lake Naivasha	Britton & Harper (2006)
0.0552	2.871	All	3.5-17.0	SL	0.978	154	Ghana	Weija	Ofori-Adu (1989)
0.0279	3.176	–	5.0-14.8	SL	0.984	36	Ghana	Volta River	Entsua-Mensah et al. (1995)
0.0115	3.21	–	7.0-15.0	TL	–	11	Nigeria	New Calabar River	Bongonyinge (1984)
0.0078	3.354	All	2.4-20.5	TL	0.993	155	Turkey	Pınarbaşı Springs Creek	Present study
0.0149	3.085	F	8.1-20.1	TL	0.983	44			
0.0179	3.016	M	8.4-20.5	TL	0.989	31			

on the negative effects of *C. zillii* introductions on native communities (Spataru 1978, Schoenherr 1988, Costa-Pierce 2003).

With regard to the population of the Pınarbaşı Springs Creek, the results of the present study showed a well-structured population with five different age classes: the presence of juveniles (0 years) indicates that the population is well acclimatised and probably it is able to reproduce naturally in the warm water of the Pınarbaşı Springs Creek.

Comparing the parameters of the length-weight relationships with those of certain native populations of the species (Table 2), the population of Pınarbaşı Springs Creek showed the highest b value for the regression calculated for the total sample, whereas the separated b values of the relationships for females and males were close to 3 (a value that indicates isometric growth). These differences probably can be due to the length composition of the sample: the regression calculated in the present study for the total sample comprises also the juvenile specimens that usually show a 'chubby' body form and b values higher than 3 (Froese 2006). Although, it cannot be excluded that this value of b could be due to the particular environmental conditions of the Pınarbaşı Springs Creek. Being the first data reported for a non-native population of *C. zillii* from Turkey, further detailed research on growth of the species and comparison with other populations throughout the non-native range is strongly recommended.

Another important result is the great number of alien species within the fish community of the Pınarbaşı Springs Creek. Among the six recorded species, only *O. anatolicus* is native to the area. This species is endemic only to some restricted habitats of the Burdur area and is currently listed as endangered according to the IUCN Red List of Threatened Species (Freyhof 2014). Although Burdur Lake is a closed basin, the area is very rich in terms of biodiversity and hosts a high number of locally endemic species. Habitat loss and degradation, water drought and the introduction of non-native species, are the main threats for these taxa. For these reasons, it is necessary to propose effective management strategies for the conservation of the endemic species and monitor the populations of non-native fish to hold back their further expansion within the area.

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