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Research article

Growth and reproduction of spotted flounder *Citharus linguatula* (L.) in Edremit Bay (Northern Aegean Sea)

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Abstract: In this study, some growth characteristics of spotted flounder, *Citharus linguatula* (L.) were investigated from 498 specimens collected in the northern Aegean coast of Turkey from September 2015 to April 2016. Total length ranged from 10.4 to 21.9 cm while weight varied between 7.6 and 73.67 g. According to the length-weight relationship, positive allometry was confirmed for both sexes with $W= 0.0033L^{3.298}$ ($R^2=0.902$). Von Bertalanfy growth rate was determined as $L_t= 27.64(1-e^{-0.21(t+1,64)})$. As the spotted flounder population in Edremit Bay consisted of 166 females and 332 males, the sex ratio was skewed in favour of males (1:2) ($p<0.05$, t-test). The monthly values of gonadosomatic index (GSI) of females indicated that spawning occurred mainly between the end of summer and the begining of winter with a peak in November while the monthly values of condition factor(CF) and hepatosomatic index (HSI) were the highest in March and November, respectively.

Keywords: *Citharus linguatula*, Edremit Bay, growth, condition, gonadosomatik index

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Introduction

The Atlantic spotted flounder, *C. linguatula* (L.), is an Atlanto-Mediterranean benthic species that inhabits soft muddy bottoms from the coastline to about 200-300m depths (Schneider, 1990). It is distributed across the Mediterranean and East Atlantic (Nielsen, 1990) and most likely to be found at depths between 10 and 100 m (Sartor et al. 2002). *C. linguatula* is also distributed in Mediterranean, Aegean and Marmara Seas, territorial waters of Turkey (Bilecenoğlu et al. 2002) and it is one of the fish species usually discarded from commercial trawl fisheries especially in Edremit Bay. and even if it is rare, it is sold in bazaars of Turkey (Özaydın et al. 2003). In Europe, Redon (1994), Sartor et al. (2002) investigated distribution and feeding of the Atlantic spotted flounder while biological parameters of the species Greek Waters by Vassilopoulou and Papaconstantinou (1994).

As to Turkish Seas, there are few published studies concerning biology, ecology, and fisheries of *C. linguatula* (Bayhan et al. 2008, 2009; Ulutürk. 2007; Cengiz et al. 2012, 2014; Ulutürk et al., 2016). However, biological studies of this species in Edremit Bay are very limited. The aim of this paper was to examine the population structure of *C. linguatula* in order to provide better knowledge and to compare the data with the relevant studies and thus help in the protection of the Atlantic spotted flounder stock in the Edremit Bay.

Materials and Methods

A total of 498 specimens of *C. linguatula* were caught by commercial fishery vessels, Akgün and Salih Reis at monthly intervals, between September 2015 and April 2016 from Küçükkuyu in Edremit Bay, northern Aegean Sea (26º57'-26º34'E and 39º17'-39º34' N).

Specimens were analysed biologically in Hydrobiology Laboratory of Faculty of Science and Arts in Balıkesir. Each fish was measured to the nearest 0.1 cm of total length (TL), using a caliper and weighed with a

balance to the nearest 0.1 g. The blind side otoliths in flatfishes, as the nucleus is more central were used for age determination (Chugunova, 1963; Lagler, 1966; Cengiz et al., 2012a). and otoliths were removed and then, soaked in 5% HCL and 3% NaOH solutions, respectively, and washed in distilled water and subsequently dried. The otoliths, placed in petri dish filled with glycerine, were read using a stereoscopic zoom microscope under reflected light against a black background. Opaque and transparent zones were counted; one opaque zone plus one transparent zone was assumed to be one year (Cengiz et al., 2013). Each individual structure was independently examined once by two readers. The length-weight relationship was calculated by applying an exponential regression equation $W=aL^b$ where, W is the weight (g), L is the total length (cm), and a and b are constants. The overall sex ratio was determined. Deviations from 1:1 hypothesis were tested statistically by chisquared analyses (Sokal and Rohlf, 1995). The spawning period of *C. linguatula* was determined by analyzing the monthly evolution of the gonado-somatic index (GSI), according to the expression: GSI=[Gonad weight/(Body weight-gonad weight)*100] (Avşar, 2016). During the reproductive cycle, physiological condition was determined monthly from the hepatosomatic index (HSI%) and the condition factor (CF). Condition factor (CF) was calculated as $CF=(W/L^3)*100$ for each sex to assess the maturity, condition of specimens and an overall measurement of being strong and healthy of the fish (Avşar, 2016). Hepatosomatic index [(HSI=(liver weight/gutted weight)×100)]: this estimates the relative size of the liver to body weight (Garcia-Diaz et al., 2006) Total instantaneous mortality rate (Z) was estimated using a length converted catch curve analysis using Fisat II (Gayanilo et al., 2005). Only fully recruited lengths were used to estimate Z. The instantaneous rate of natural mortality (M) was estimated using two methods: (1) Pauly's method (Pauly, 1984), $\log10M= 0.0066–0.279 \log10L\infty + 0.6543 \log10K+0.4634 \log10T$, where $L\infty$ is the asymptotic length (cm), K the Brody growth coefficient from the von Bertalanffy growth model and T the mean annual bottom temperature; Fishing mortality (F) was estimated as F=Z–M. The exploitation rate was also estimated as E=F/Z (Sparre and Venema, 1992).

Results

Length and weight frequency distribution

The total length ranged from 10.4 to 20.9 cm, with length intervals of 15.4-15.9 cm being the most dominant in the sample (Figure 1), while The weight ranged from 7.60 to 73.67 g., with weight intervals of 28.6-31.6 g. being the most dominant in the sample (n=498) (Figure 2).

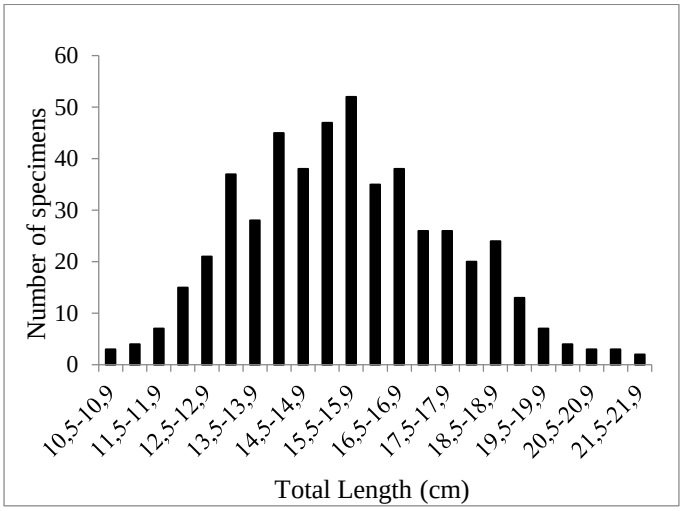

Figure 1. Total length frequency distribution of all *Citharus linguatula* specimens from Edremit Bay between the years of 2015-2016

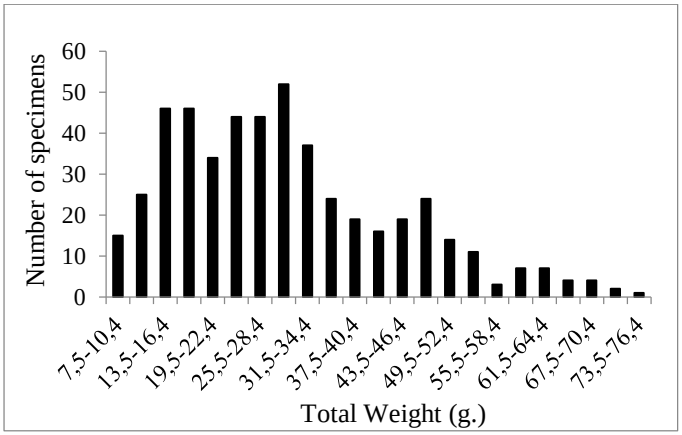

Figure 2. Total weight frequency distribution of all *Citharus linguatula* specimens from Edremit Bay between the years of 2015-2016

Age composition and sex ratio

Age and sex distribution data are summarized in Figure 3. Age of captured fish ranged between I and V, while the second year class was dominant with 66.65%. Because of selectivity of the nets, the 0 age group was not represented in the sampling. Sex ratio of the population consisted of about 66.69% males with 332 specimens and 33.31% females with 166 ones, and differences between sexes according to age were statistically significant (t-test, $P<0.05$) with the sex ratio (F:M=1:2).

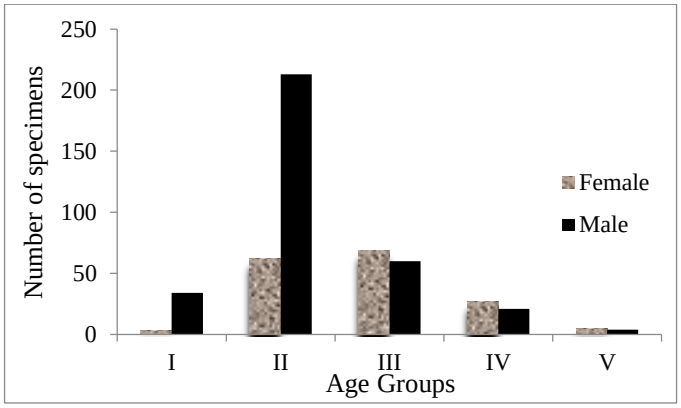

Figure 3. Age groups and sex ratio of all *Citharus linguatula* specimens from Edremit Bay between the years of 2015- 2016.

Growth

The age–weight relationship in all individuals was estimated as Lt = 27.64[1-$^{e-0.21}$ (t+1.64)] with the growth performance, 2.447

Length–weight relationship

Length–weight relationship was calculated by using the data of 498 *C. linguatula* specimens. This was plotted as W = 0.0033L$^{3.298}$ for all specimens (R^2=0.902) in Figure 4.

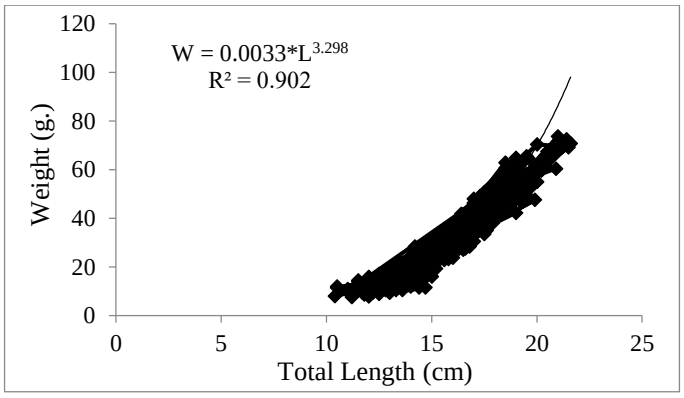

Figure 4. Length-weight relationship of all *Citharus linguatula* specimens from Edremit Bay between the years of 2015-2016.

Condition factor (CF%)

Monthly seasonal conditions exhibited a similar pattern for all individuals, showing a peak in March (Figure 5).

Gonad development and spawning period (GSI%)

Gonad development was followed using the GSI. Monthly changes are plotted in Figure 5. Spawning occurred between September and December, showing a peak in November.

Hepatosomatik indeks (HSI%)

In general, monthly HSI values exhibited a similar pattern for both sexes, showing a peak in November (Figure 5).

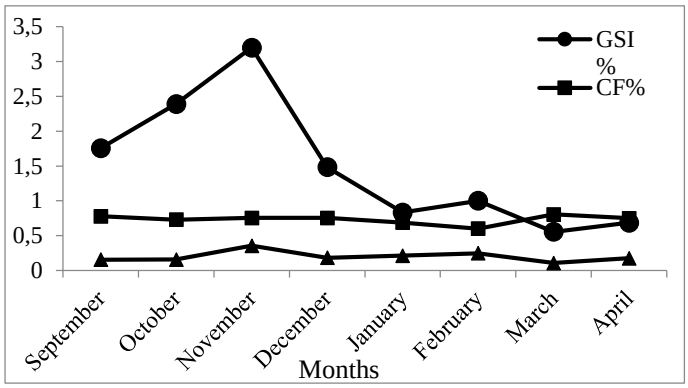

Figure 5. The comparisons of monthly HSI, CF, and GSI values of all *Citharus linguatula* specimens from Edremit Bay between the years of 2015-2016.

Mortality parameters

The values of mean Z, M, and F were calculated as Z = 0.5 year-1, M = 0.35 year-1, F = 0.15 year-1 in the 2015-2016 fishing season, respectively. The exploitation rate (E) was 0.3.

Discussion

The spotted flounder population in Edremit Bay. otolith age-readings indicate that the the population ranged between I and V. The fact that 2 age was dominant for population. indicated that the population consisted of mostly young individuals (Figure 1). The ages of the *C. linguatula* population are smiliar to that recorded by Pappa et al. (2017) except for a study by Belghytp et al. (1994). In the spotted flounder population in Edremit Bay, the population consisted of 66.6% males and 33.4% females, and the sex ratio of 1:2 (F:M), estimated to be significantly different from 1:1 (χ2, p<0.05). Our findings are a harmony with those estimated from Saros Bay by Cengiz et al. (2014). Although the sex ratio in most of the species was close to 1, this may vary from species to species, differing from one population to another of the same species, and may vary year after year within the same population (Nikolsky, 1980). Variations in fish growth in terms of length and weight can be mentioned as an adaptition to different bio-ecological conditions (Wootton, 1992). The von Bertalanffy growth equation was: Lt= 27.64[1-$^{e-0.21}$ (t+1.64)] for combined sexes in the Edremit

Bay. The theoretical maximum length was close to especially those estimated for Izmir Bay, except for Aegean Sea. Maximum lengths recorded prior to our study were 14.2 and 28.0 cm (Table 1). This variation may be due to different stages in ontogenetic development, as well as differences in condition, length, age, sex and reproduction (Ricker, 1975). Geography and some environmental factors such as temperature, organic matter, quality of food, time of capture, stomach fullness, disease, parasitism can also affect weight at-age estimates (Bagenal and Tesch, 1978). Froese (2006) also mentioned that "a" and "b" parameters of WLR equation were affected by several reasons such as gonad development, habitat differences, sex, diet, fishing methods and number of specimens. Positive allometric growth was observed in all specimens in Figure 3. Similar results have been reported from other areas in the Aegean Sea, Egyptian Mediterranean waters and eastern Adriatic (Vassilopoulou and Papaconstantinou, 1994; Dulcic and Kraljevıc, 1996; Abdallah, 2002), except for those found by Moutopoulos and Stergio (2002) and Sartor et al. (2002) (Table 1).

In the present study, spawning occurred between September and December with the peak in November for Edremit Bay population (Figure 5). Spawning season in Edremit Bay is seen to be similiar to some relevant studies (Table 2). Due to different ecological and climate conditions, the start and finish time of reproductive period may happen during different months (Nikolsky, 1980).

Table 2. Spawning seasons of *Citharus linguatula* at various localities according to previous studies

Locality	Months												References
	J	F	M	A	M	J	J	A	S	O	N	D	
Eastern Adriatic								■	■	■	■		Grubisic (1962)
Mediterranean								■	■	■	■		Sabates (1988)
Portuguese Coast									■	■	■		Teixeira et al. (2010)
Saros Bay									■	■	■		Cengiz et al., 2014
İzmir Bay								■	■	■	■		Ulutürk et al. (2016)
Patraikos Bay									■	■	■		Pappa et al. (2017)
Central Aegean Sea									■	■	■		İlkyaz et al. (2018)
Edremit Bay									■	■	■	■	This study

For a better evidence of the natural life conditions of the *C. linguatula* in Edremit Bay, seasonal condition has been calculated. According to Figure 5, maximum condition factor was found in March, being generally higher just prior to spawning season and lower after spawning.

As seen in Figure 5, the hepatosomatic index shows the highest value in November. The hepatosomatic index is an indicator of feeding activity of fish (Tyler and Dunn, 1976). The hepatosomatic index shows an allocation of energy to the liver during every period except reproduction, when part of the energy is used for gonad maturation (Nunes and Hartz, 2001). In this study, the values of hepatosomatic index are found to be following a similar trend to values of gonadosomatic index (Figure 5). This is accordance with the different species studied by Asahina et al. (1990), Çek et al. (2001), Kingdom and Allison (2011). Since total fish length and weight are included in the calculation of GSI and HSI, they are possible to present an auto–corelation.

Pauly (1980) reviewed natural mortality rates for 174 fish stocks, and modal mortality was 0.2-0.3 Obtained values of the natural mortality of the Atlantic spotted flounder in the area of study indicate a relatively low natural mortality M = 0.35. The same species may have different natural mortality rates in different areas depending on the density of predators and competitors, whose abundance is influenced by fishing activities (Sparre et al., 1989). Direct measurements of M are often impossible to obtain, so identification of quantities which can be assumed to be proportional to M and which are easier to measure (or estimate) has been attempted. An estimate of M by Pauly's formula belongs to the category of qualified guesses. We must also take into account that quality of the input data to the regression analysis from which Pauly's formula was derived can be questioned, since Pauly needed real observations of M which are difficult to obtain. So, any M value which was used for estimation can be questioned. For some species, the values of M seem to be twice or half of what it should be (Sparre and Venema, 1992). Even small changes in the growth parameters used could affect the computed mortality rates (Tserpes and Tsimenidis, 2001). It is rather difficult, probably unwise, to describe the current position of the stock due to the lack of information on the effect of fishing on recruitment and behaviour pattern of spotted flounder. However, the exploitation ratio E = 0.3, revealed light to

moderate exploitation of stocks in the studied area. The fisheries strategy should be planned so that the fishing period follows the reproductive period. Most of the estimates of E, for Atlantic spotted flounder from the Aegean Sea (Vasillopoulou and Papaconstantinou, 1994) were around 0.32 suggested that a fish stock is exploited lower than a level of F which generates E = 0.5.

Conclusions

Edremit Bay, in the northern Aegean Sea, is a place where two currents meet and plankton is abundant because of upwelling. In addition, because the bottoms are suitable for trawl fishing and the area is fed by waters rich in nutrient from erosion through the vicinity of the bay and the Black Sea, there is a rich bottom fish fauna. With these facilities, Edremit Bay has a high potential to be a nursery for both pelagic and demersal species and for sea food, especially fish (Toğulga, 1997). For this reason, trawl forbidden in Edremit Bay (Anonymus, 1995; Çelik and Torcu, 2000), has positively affected the Atlantic spotted flounder population. Although this species has minor commercial importance, it is an abundant and harvested as a discard in bottom trawls. The data of this study will be hopeful to help conservation and management of *C. linguatula* stocks in Edremit Bay.

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