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Age and feeding habits of Atlantic spotted flounder *Citharus linguatula* (Linnaeus, 1758) (Pisces: Pleuronectiformes) from central Aegean Sea of Turkey

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Abstract. Age and feeding habits of Atlantic spotted flounder, *Citharus linguatula*, from Izmir Bay (central Aegean Sea coast of Turkey) were studied. Total length ranged between 6.8 and 23.2 cm. Overall female: male ratio was 1:1.34 and age distribution of the samples I and IV years (otolith readings). Atlantic spotted flounder grew positively allometrically (b=3.273±0.031, 95% confidence level). Growth parameters of the *C. linguatula* population were: L_∞=26.21 cm, K=0.301 year^{-1}, t_0=-0.621 years for all individuals. Growth index (Φ') was calculated as 2.32. Stomach analyses indicated that the species feeds on four major groups of prey: Polychaeta, Crustacea, Mollusca and Teleostei. According to a Bray-Curtis similarity index for ages, two groups were formed based on index percentage of relative importance of food items; I, II and III age groups constituted the first similarity and IV the second one.

Key words: Atlantic spotted flounder, *Citharus linguatula*, age, feeding habits, Izmir Bay, Aegean Sea.

Introduction

The Atlantic spotted flounder, *Citharus linguatula* (Linnaeus, 1758), is an Atlanto-Mediterranean benthic species that inhabits soft muddy bottoms from the coastline to about 200-300m depths. It is distributed across the Mediterranean and East Atlantic (Nielsen 1986) and most likely to be found at depths between 10 and 100 m (Sartor et al. 2002). Like scaldfish, *Arnoglossus laterna*, in Izmir Bay, central Aegean Sea of Turkey (Bayhan et al. 2008), *C. linguatula* is distributed in Mediterranean, Aegean and Marmara Seas, territorial waters of Turkey (Bilecenoglu et al. 2002) and it is one of the fish species usually discarded from commercial trawl fisheries.

Flatfish are an economically and ecologically significant component of continental shelf, deep ocean, small marine areas and estuarine ecosystems across the world. Flatfishes serve as a major energy pathway for conversion of benthic production into a form suitable for consumption by higher predators (Link et al. 2005). However, since it is not commercial fish, detailed information on its biology and ecology is not available in the literature. Consequently there are a few studies (Vassilopoulou & Papaconstantinou 1994, Cakir et al. 2005) on population biology of *C. linguatula* in the

Aegean Sea. Nevertheless, comprehensive feeding regime of the species has been established for the Adriatic Sea (Jardas 1984) and Spanish shores of the north-western Mediterranean (Redon et al. 1994, de Juan et al. 2007). On the other hand, no study is found about its feeding habits in the Aegean Sea and those in other Turkish Seas and the western Mediterranean.

The purpose of this study is to investigate some growth characteristics and feeding habits of *C. linguatula* which has been significantly harvested among the fish populations in Izmir Bay, central Aegean Sea. Also the present study provides baseline information on the feeding regime of *C. linguatula* for the western Mediterranean, including the Aegean Sea, which will thus be useful for fish biologists and fisheries managers in future.

Materials and Methods

A total of 1429 specimens were caught with conventional demersal trawl net (44mm cod-end mesh size) in Izmir Bay between January 2002 and March 2003 (Fig.1). The sex ratio was determined by investigating the gonads of the individuals and additionally, total length (TL) and total weight (TW) were measured with 1mm and 0.01g. precision, respectively. Sex was macroscopically identified in the samples. Sex ratios were compared to the 1:1 and χ^2 (Chi-square) test used to determine the importance of male to female ratio (Zar 1999).

Both sagittal otoliths were removed from specimens and cleaned in distilled water. Those of 470 individuals selected randomly to represent all length groups were removed then stored in enve-

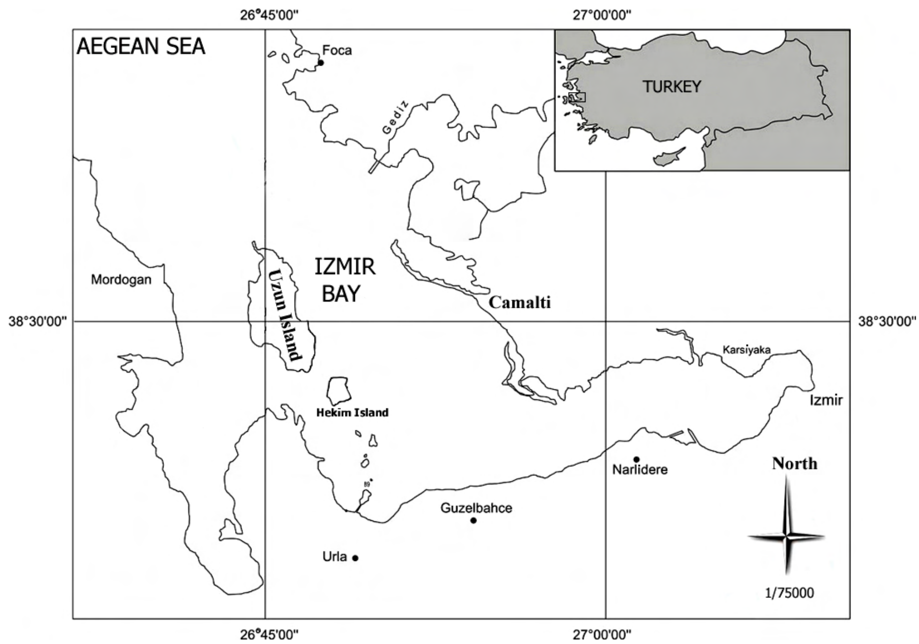

Figure 1. Sampling locality of *Citharus linguatula* in Aegean Sea.

lopes under dry conditions and placed in a black dish with glycerin (30%) and alcohol (70%) to improve readings. The translucent bands observed under a stereoscope with reflected light (30 magnifications) were counted.

Length-weight relationship of specimens was calculated by log transformed data,

$$\log W = \log a + b \log L$$

where (W) is the total weight (g), (L) the total length (cm), (a) the intercept and (b) the slope or allometric coefficient. Allometric coefficient (b), which is larger or smaller than 3.0, shows an allometric growth (Bagenal & Tesch 1978). For estimating the individual growth rate, the von Bertalanffy growth equation (VBGF) for length was used:

$$L_t = L_\infty [1 - e^{-k(t-t_0)}],$$

where L_t is the total length at age t, L_∞ the asymptotic total length, k the growth curvature parameter and t_0 the theoretical age when fish would have been at zero total length (Sparre & Venema 1992).

Overall growth performance of a species can be interpreted by the growth index:

$$\Phi' = \log (K) + 2 \log (L_\infty)$$

which can also be used for comparing growth rates among species (Munro & Pauly 1983). T test was used to test the importance of the difference between length and weight of the males and females. Since the difference between length and weight of the males and the females was not significant, all individuals were assessed as a whole.

Stomachs were removed from all fish soon after capture and preserved in 4% formalin solution for later analysis. The stomach contents were directly examined under a stereoscopic binocular microscope and then determined to the lowest possible taxon. Once counted, the individuals of the same species were weighed together (wet weight to the nearest 0.0001g), after excess moisture was removed by blotting prey items on tissue paper. The contribution of the different categories of food items to the diet of *C. linguatula* were determined by: frequency of occurrence (%F) numerical occurrence (%N) and weight (%W) (Hyslop 1980), and the index of relative importance (IRI and %IRI) calculated (Pinkas et al. 1971, Cortes 1997). In order to assess feeding intensity, vacuity index was employed (%VI: empty stomachs/total number of stomachs*100).

Results and Discussion

Minimum and maximum total length and weight values of females, males and all fish were between 7.70-21.70cm, 2.28-67.30g; 6.80-22.0cm, 2.24-78.82g; and 6.80-23.20cm, 2.24-107.80g, respectively (Table 1). Length and weight values were found to be statistically insignificant involving sex in the population of *C. linguatula* ($t=0.02$; $p>0.05$). Within the population of this species, most of the individuals of our samples distributed between 10 and 17cm (64.87%), the minimum and maximum total lengths of the specimens are 6.8cm and 23.2cm respectively (Fig.2). A total of 696 specimens were used to determine sex, with and 42.8% being female and 57.2% male. The overall ratio of males to females was 1:1.34. Difference between sexes ($\chi^2=71.84$, $p<0.05$) was observed for female:male ratio.

Relationship between total length and weight for females, males and all individuals is described by the equations: $W=0.0028L^{3.305}$ ($r^2=0.990$; $b=3.305\pm0.002$, 95% CI; n=298), $W=0.0031L^{3.262}$ ($r^2=0.987$; $b=3.262\pm0.031$, 95% CI; n=398) and $W=0.0032L^{3.273}$ ($r^2=0.985$ $b=3.273\pm0.031$, 95% CI; n=1429) respectively. Positive allometric growth was observed for male, female and all fish. Some the findings of length-weight relationships in *C. linguatula* in Turkish and other seas are in positively allometric growth (Vassilopolou & Papaconstantinou 1994, Dulčić & Kraljević 1997, Abdallah 2002, Cakir et al. 2005, Karakulak et al. 2006) the others within a range of negatively allometric growth (Petrakis & Stergiou 1995, Moutopoulos & Stergiou 2002, Santos et al. 2002, Ozaydin & Taskavak 2006). Such differences in values b can be ascribed to one or a combination of more of the factors

Table 1. Range, mean and standard error (SE) of total length (cm) and weight (g) for *Citharus linguatula* in Izmir Bay, Turkey by sex and for all fish together.

		N	Range	Mean	SE
Females	Total length	298	7.70-21.70	14.45	0.561
	Weight	298	2.28-67.30	35.47	2.663
Males	Total length	398	6.80-22.00	14.55	0.535
	Weight	398	2.24-78.82	34.79	2.364
All fish	Total length	1429	6.80-23.20	14.85	0.297
	Weight	1429	2.24-107.80	36.25	1.276

including differences in the number of specimens examined, area/season effects and distinctions in the observed length ranges of the specimens caught, to which duration of sample collection can be added as well (Moutopoulos & Stergiou 2002).

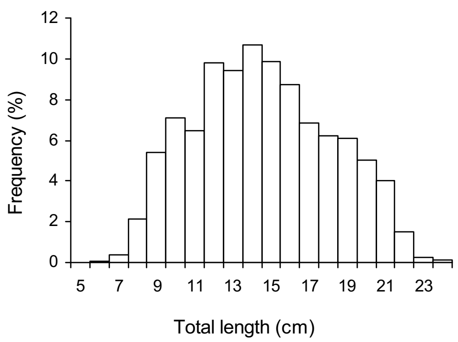

Figure 2. Frequency analysis of total length in *Citharus linguatula* (N=1429).

The age distribution of individuals belonging to the *C. linguatula* populations was from I to IV. Most of the individuals were obtained from the II year old group, followed by the III and IV year old groups in regard to number of individuals (Table 2). No significant difference was found between the average length of the individuals caught in nature according to each age group and the theoretical average length calculated by the von Bertalanffy equation ($p>0.05$; $t=-0.087$). Parameters of Von Bertalanffy's growth equality were calculated for all individuals. According to these calculations $L\infty$ was found to be 26.21 cm, k 0.301 year and t_o -0.621. For all individuals, the growth model was: $Lt=26.21[1-e^{-0.301(t+0621)}]$. Age data represent valuable information concerning the life history of a fish species. However, reliability of the age determination on size of the samples studied and interpretation of the growth zones depends largely on reading otoliths. Our age range (1-4 years) is within the longevity limits observed by Cakir et al. 2005 as 4 years, as compared to those by Vassilopoulou & Papaconstantinou 1994 as maximum for males 5 and for females 7. Differences in longevity have been attributed to latitudinal differences as well as to the effects of temperature, food availability and life history strategies. The pattern of commercial exploitation is probably the most significant factor to cause local differences in longevity (Rash & Geffen 2005).

The contents of 432 *C. linguatula* stomachs were analyzed. Of the total number of stomachs examined, 23.6% of which were

Table 2. Age-length (%) key of *Citharus linguatula* in Izmir Bay (MTL=mean total length; SD=standard deviation; N=number of specimens in each length group).

Length group TL (cm)	Age I	II	III	IV
6.10-7.00	100.00			
7.10-8.00	100.00			
8.10-9.00	92.86	7.14		
9.10-10.00	25.58	74.42		
10.10-11.00	24.24	72.73	3.03	
11.10-12.00	8.20	73.77	18.03	
12.10-13.00	6.90	44.83	48.28	
13.10-14.00		22.73	40.91	36.36
14.10-15.00		16.98	37.74	45.28
15.10-16.00		11.11	68.25	20.63
16.10-17.00			28.07	71.93
17.10-18.00			35.29	64.71
18.10-20.00				100.00
20.10>				100.00
MTL	10.37	14.33	17.98	19.85
SD	1.06	2.11	2.32	2.46
Total (%)	15.96	30.21	28.72	25.11

empty and 76.4% full. The overall diet composition revealed that the Atlantic spotted flounder feeds mostly on benthic crustaceans especially mysids (IRI%=52.95) and teleosts (IRI%=14.96). Polychaetes (IRI%=1.09) and molluscs (IRI%=0.13), were of minor importance. Considering seasonality of this species' stomach contents, benthic crustaceans is the group found predominantly. While mysids is the group consumed most in every season, amphipods are found abundant in winter, decapods in fall, and Euphausiacea during all the seasons except autumn. Species of benthic copepoda were found infrequently. Fish eggs and larvae were consumed in almost equal amounts in every season. Teleosts were able to be identified from stomachs examined, in order of significance as follows: Callionymidae and Gobiidae (Table 3).

In the study in which a total of ten prey groups were established, amphipods and mysids were found most abundant in weight (%W), whereas mysids and teleostei found most plentiful in numerical quantity (%N). Considering the stomach content of the species in weight, amphipods and mysids were established as significant prey groups, followed by decapods and teleosts whose body tissues were found less digested in the stomachs. Because those of natantia, copepods and molluscs (Cephalopoda) were too extremely digested, their weight values were quite insignificant (Fig.3). Similarly Jardas (1984) reported that the species feeds on teleosts (especially *Lesuerigobius friessii, Cepola macrophthalma, Merluccius merluccius*), natantia and mysids in particular. Also according to Redon (1994), who studied the eastern coast of Spain, mysids, euphasiids, shrimps, squid and fish constituted the major prey items.

There were some fluctuations in the feeding intensity throughout the age groups. According to the examination of diet composition related to age, two groups were formed by IRI percentage of food items. %IRI composition of prey ranged between 1.2 and 84.4 for I and IV age groups, with prey diversity increasing for those larger than in III, primarily due to a diet shift to teleost larvae, which may be associated with the variations of the prey availability in the feeding ground. The older they are the wider mouth they will have; thus they will add the small fishes into their diets (Fig.4). Similarly the smaller *C. linguatula* (<10 cm) mostly ingested the crustaceans, and the larger individuals (15-25 cm) increased the ingestion of fish, according to de Juan et al. (2007), confirming findings by Redon et al. (2004). Flatfish species are able to eat a wide range of prey (Amezcua et al. 2003). Our findings support previous studies indicating that *C. linguatula* feeds mainly on benthic crustaceans and fishes.

Table 3. Index of relative importance (%IRI) in prey groups by seasons for *Citharus linguatula* in Izmir Bay (Aegean Sea) (N: number of fish stomach; TL: total length of fish; SE=standard error).

	Winter	Spring	Summer	Autumn	Total
N (examined stomach)	118	110	96	108	432
Mean TL (cm)	15.4	14.8	14.5	15.7	15.1
SE	0.16	0.13	0.29	0.21	0.17
Prey groups					
Polychaeta	2.07	0.21	0.73	1.41	1.09
Crustacea					
Copepoda	0.63	0.11	0.21	0.50	0.37
Mysidacea	31.26	68.00	62.08	50.74	52.95
Euphausiacea	8.87	8.96	10.07	2.30	8.46
Isopoda	2.06	0.03	0.08	0.57	0.54
Amphipoda	24.31	0.62	1.14	1.60	8.42
Natantia	1.76	-	-	0.42	0.29
Decapoda	12.65	10.40	11.11	15.31	12.79
Mollusca					
Cephalopoda	0.52	-	-	0.35	0.13
Teleostei	15.87	11.66	14.58	12.79	14.96

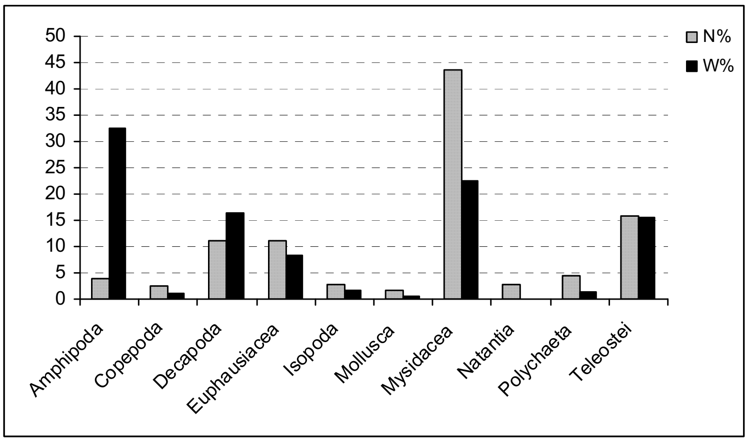

Figure 3. Values of percentage weight (%W) and percentage numerical amount (%N) of significant prey groups in feeding of *Citharus linguatula*.

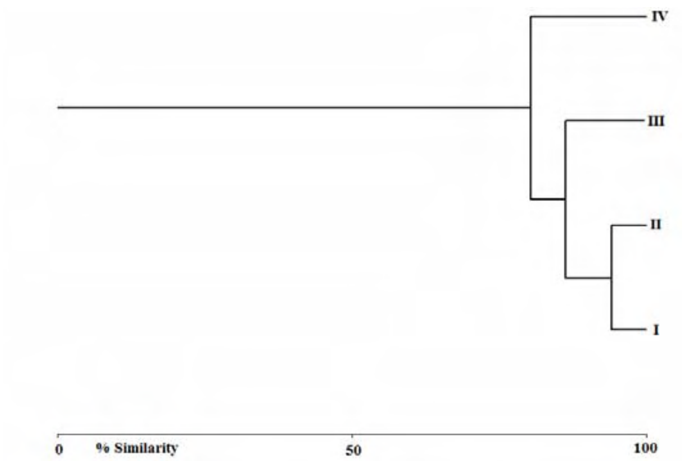

Figure 4. Dendrogram of similarity between age groups based on %IRI of prey in *Citharus linguatula* stomachs, Izmir Bay.

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