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Age, Length-Weight Relationships and Diet Composition of Scaldfish *Arnoglossus laterna* (Walbaum, 1792) (Pisces: Bothidae) in Izmir Bay (Aegean Sea)

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Abstract: The age, length-weight relationship and diet composition of *Arnoglossus laterna* from the Izmir Bay were examined in specimens caught on a seasonal basis from January 2002 to March 2003. The ratio of male to female of 1081 scaldfish captured by trawl netting was 1:1.62 and their total lengths varied from 5.6-15.7 cm and total weights from 1.2-31.51 g. The length-weight relationships were estimated as $W = 0.0035\ L^{3.301}$; $W = 0.0066\ L^{3.043}$; $W = 0.0073\ L^{3.011}$ for females, for males and for all individuals, respectively. Based on the otolith readings, the age distribution of the samples varied from I to V years. The von Bertalanffy growth parameters were calculated to be $L_\infty = 16.87$ cm, $k = 0.236$ year^{-1}, $t_0 = -0.887$ year. Stomach contents of *A. laterna* were filled with preys of 5 major taxonomical groups: *Polychaeta*, *Crustacea*, *Mollusca*, *Chaetognatha* and *Teleostei*. A total of 11 prey groups were identified in the diets of scaldfish, with most abundant crustaceans. According to a Bray-Curtis similarity index in relation to ages, two groups are formed based on index percentage of relative importance of food item; I-II age groups constituted the first similarity and III-IV-V the second one.

Key words: Scaldfish, *Arnoglossus laterna*, age, length-weight relationships, diet composition, Izmir Bay, Aegean Sea

INTRODUCTION

Arnoglossus laterna (Walbaum, 1792) is a demersal flatfish of the Bothidae family distributed in the Mediterranean and Black Seas. It is most likely to be found at 200 m depth (Nielsen, 1986). A 0-group scaldfish occurred from 15-70 m with peak numbers at about 35 m in the southern North Sea (Baltus and Van der Veer, 1995). In the territorial waters of Turkey *A. laterna* is distributed in Mediterranean, Aegean, Marmara and Black Seas (Bilecenoglu *et al*., 2002). *A. laterna* is fish species discarded from commercial trawl fisheries in Izmir Bay, central Aegean Sea of Turkey.

Flatfish are an economically and ecologically significant component of continental shelf, deep ocean, small sea 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 and humans. As such, they are a critical component of benthic communities Link in Gibson (2005). Also, *A. laterna* is one of the preys of piscivor demersal fish (Olaso *et al*., 2004; Carpentieri and Collaca, 2005). However, since it is not a commercial fish, detailed information on its biology and ecology is absent and elements to influence its distribution or habitat requirements hardly understood (Amara *et al*., 2004).

There are few studies on population biology of *A. laterna* from other seas. Deniel (1990) reported some knowledge of biological parameters of *A. laterna* in Douarnenez Bay, Brittany. Additionally, valuable information on age, growth and mortality of *A. laterna* were reported by Djabali *et al.* (1993). Gibson and Ezzi (1980) studied the biology of the scaldfish from the west coast of Scotland. Studies on diet composition of the species were conducted by Gibson and Ezzi (1987) and of some other species including it by Darnaude *et al.* (2001); Cabral *et al.* (2002), Cartes *et al.* (2002) and Amezcua *et al.* (2003). However, several studies were made concerning its length-weight relationships in particular (Pereda and Villamor, 1991; Giovanardi and Piccinetti, 1983; Merella *et al*., 1997).

For Turkish seas on the other hand, only Özütok and Avsar (2002) reported some information on growth and mortality of *A. laterna* individuals captured in the Yumurtalik Bight (Mediterranean coast of Turkey) and diet composition of scaldfish was studied by Avsar (1994) there. Studies made along Turkish Aegean Sea are

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mostly related to length-weight relationships (Mater and Sahinoglu, 2000; Cakir *et al*., 2003; Ozaydin and Taskavak 2006; Karakulak *et al*., 2006). However, there are no studies made on the population biology and diet composition of *A. laterna* in the central Aegean Sea coast of Turkey.

The aim of the study, is to determine age, growth, length-weight relationships and diet regime of *A. laterna* and compare them with those of the research made in other seas on this issue. We expect the study to be also of great use in other fish of economic value in capture.

MATERIALS AND METHODS

In order to determine age, growth and stomach contents of *A. laterna*, all specimens were collected by a conventional demersal trawl net with 44 mm cod-end mesh size from January 2002 to March 2003 in the Izmir Bay, central Aegean Sea coast of Turkey (Fig. 1). Total length (TL) of 1081 scaldfish were measured to the closest 0.1 cm and total body weight (W) to the closest 0.01 g. Sex was macroscopically identified in the samples; male:female compared to the 1:1 proportion.

The otoliths of 555 individuals selected randomly to represent all length groups were removed and then stored in envelopes under dry conditions. Both types of sagittal otoliths were washed and cleaned in NaOH solutions several times for 24 h and ages of the otoliths determined under the stereomicroscope in reflected light (×30 magnification). Otoliths were independently read on the major axis of the proximal surface (longitudinal plane) by three readers, irrespective of fish length. Agreement not reached, the otoliths concerned were excluded from the growth estimations. To estimate 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 and Venema, 1992). Since, the difference between the length and weight of males and the females was not significant, all individuals were assessed by von Bertalanffy growth equation. 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 and Pauly, 1983).

Total length of all specimens was employed to calculate Length-Weight Relationship (LWR) which was measured 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. 95% confidence intervals of b was calculated to detect a strong deviation from the isometric growth of $b = 3$.

Fish were dissected as soon as they had been captured and their stomachs removed and stored in formalin (4%) until the contents were analyzed. Stomach contents were examined under a SZX7 Olympus stereo microscope with a zoom of 0.8-5.6x and resolution of 10x. Once counted, the individuals of the same species were weighed together (wet weight to the nearest ±0.0001 g)

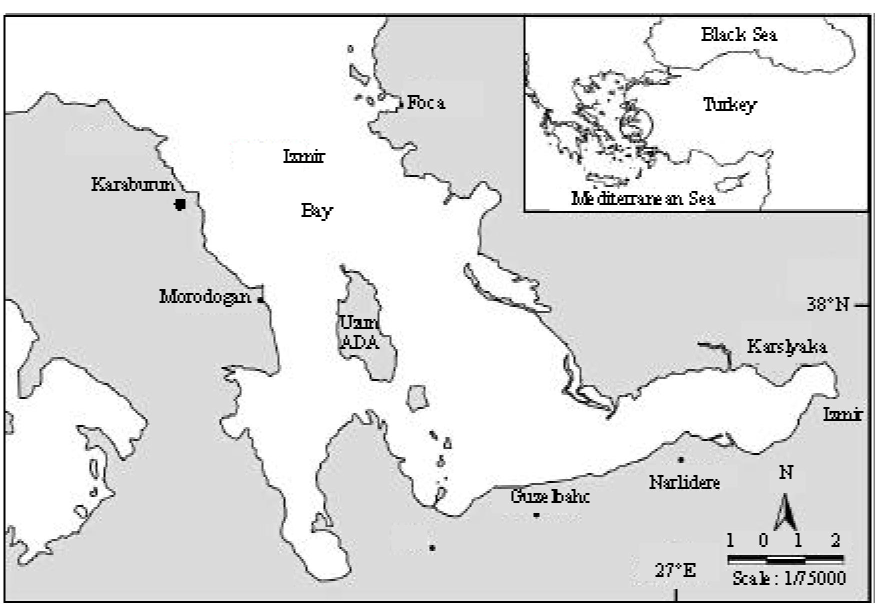

Fig. 1: Sampling locality of *Arnoglossus laterna* in Aegean Sea

and later excess moisture was removed by blotting prey items on tissue paper. The following indices were used to quantify the importance of different prey items in the diet (Hyslop, 1980): percentage frequency of occurrence (%F), percentage numerical abundance (%N) and percentage gravimetric composition (%W). The main food items were identified using the index of relative importance, IRI = (%N + %W) × %F (Pinkas *et al*., 1971). IRI was also expressed as a percentage: %IRI = (IRI / ΣIRI) × 100. In order to assess feeding intensity, vacuity index was employed (%VI: empty stomachs/total number of stomachs × 100).

RESULTS AND DISCUSSION

Age and length-weight relationships: A total of 656 specimens were used to establish sex with 38.1% being female and 61.9% male. The overall ratio of males to females was 1:1.62. Minimum and maximum weight and total length values of all fish were 1.20-31.51 g and 5.6-15.7 cm, respectively. Length and weight values were found to be statistically not significant concerning sex in the population of *A. laterna* (t = 0.04; p>0.05). Relationships between fork length and weight for females, males and all individuals combined are described by the equations: $W = 0.0035 L^{3.301}$ ($r^2 = 0.962$; b = 3.301±0.106 95% CI; n = 250), $W = 0.0066 L^{3.043}$ ($r^2 = 0.969$; b = 3.043±0.067, 95% CI, n = 406) and $W = 0.0073 L^{3.011}$ ($r^2 = 0.968$; b = 3.011±0.033, 95% CI; n = 1081). Comparison of *A. laterna* length-weight relationships are shown in Table 1.

A sample of 555 specimens was used for age determination. The age distribution of individuals of the scaldfish populations was I to V. Maximum TL observed was 15.70 cm of a 5 year-old fish. Most of the individuals were obtained from the group of II year followed by the group of III and IV year old in number of individuals (Table 2). No statistically significant difference was found between and 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 = -0.123). The von Bertalanffy growth curve in the observed lengths-at-age provided parameters of L_∞ = 16.87, k = 0.236 and t_0 = -0.887. Various growth parameter estimations of *A.laterna* are shown in Table 3.

Data of age represent precious information on the life history of a fish species. However, reliability of the age determination largely depends on size of the samples investigated and interpretation of the growth zones on the otoliths. Flatfish follow the general trend among fishes with longevity greater in larger species. In contrast, the species Bothidae is thought to live up to 10 years (Gibson, 2005). The age range of 1-5 years

Table 1: Comparison of *Arnoglossus laterna* length-weight relationship parameters (a:intercept, b: slope)

Author(s)	n	L_{min}-L_{max}	W = aL^b a	b	r^2
Pereda and Villamor (1991)	35	5.0-14.0	0.0024	3.389	0.941
Giovanardi and Piccinetti (1983)	-	-	0.0045	3.000	-
Merella *et al.* (1997)	20	8.0-13.0	0.0025	3.450	0.925
Mater and Sahinoglu (2000)	643	6.0-15.3	0.0093	2.898	0.940
Ozutok and Avsar (2002)	390	3.9-13.8	0.0050	3.117	0.852
Ozaydin and Taskavak (2006)	721	6.8-21.9	0.0052	3.168	0.960
Karakulak *et al.* (2006)	8	7.6-18.3	0.0150	2.117	0.991
Present study (all)	1081	5.6-15.7	0.0071	3.024	0.968

Table 2: Age-length key of *Arnoglossus laterna* 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	V	N
5.00-6.00	1					1
6.10-7.00	12	6				18
7.10-8.00	5	94	2			101
8.10-9.00	4	42	44	25		115
9.10-10.00		30	68	39		137
10.10-11.00		31	37	56	1	94
11.10-12.00			15	19	11	45
12.10-13.00			1	12	9	22
13.10-14.00				8	7	15
14.10-15.00					5	5
15.10-16.00					2	2
MTL	6.1	8.4	10.6	12.1	13.2	
SD	0.85	2.05	2.33	2.76	2.69	
N	22	173	165	160	35	555

Table 3: Various growth parameter estimations of *Arnoglossus laterna*

L_∞ (cm)	k	to	Ø'	Locality	Author(s)
15.20 (male)	1.032	0.770	2.38	Douarnenez Bay	Deniel (1990)
15.80 (female)	0.840	0.690	2.32		
15.80	0.570	-	2.15	Adriatic Sea	Djabali *et al.* (1993)
15.90 (male)	0.140	1.710	1.55	Yumurtalik Bight	Özütok and Avsar (2002)
14.60 (female)	0.150	1.000	1.50		
15.60 (all)	0.130	1.540	1.50		
16.87 (all)	0.236	0.887	1.83	Izmir Bay	Present study

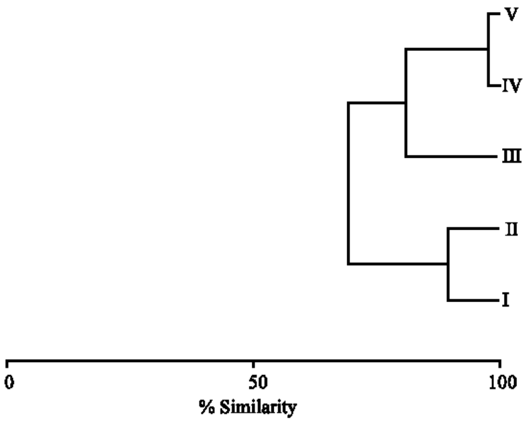

Fig. 2: Dendrogram of similarity between age groups based on %IRI of prey in *Arnoglossus laterna* stomachs, Izmir Bay

is within the longevity limits in the present study and it was observed by Gibson and Ezzi (1980) as maximum 8+ years; Deniel *et el*. (1990) as 7.5; Djabali *et al*. (1993) as 4; and Ozutok and Avsar (2002) as 8. The growth performance index values estimated in the present study were similar to those of other studies (Table 3).

Diet composition: Of a total of 540 scaldfish stomachs examined, 70 were empty (13%). Vacuity index was low during spring (10%) and autumn (11%) but slightly higher in winter (16%) and summer (15%). Stomach contents of *A. laterna* were filled with preys of five major taxonomical group (*Polychaeta*, *Crustacea*, *Mollusca*, *Chaetognatha* and *Teleostei*). Scaldfish fed mainly on crustaceans, especially mysids (IRI = 4998.92; IRI% = 54.45). Teleosts (IRI = 763.16; IRI% = 8.31) and polychaets (IRI = 661.52; IRI% = 7.21) were of minor importance (Table 4). Teleosts (eggs and juvenile stages) could be identified from stomachs examined, in order of significance as follows: Callionymidae, Gobiidae and Mullidae.

Mysids were the primary food item in all seasons. A clear peak of teleosts were observed during autumn and winter, sharply decreasing to %IRI <1 in rest of the year (Table 5). A comparison of seasonal %IRI values of major taxonomical groups based on Bray-Curtis index revealed that spring and summer were 94.11% similar whereas the winter was different from other seasons.

Table 4: Diet composition of *Arnoglossus laterna* (%F:frequency of occurrence, %N:percentage numerical composition, %W:percentage gravimetric composition, IRI: index of relative importance) from Izmir Bay

Prey groups	N%	F%	W%	IRI	IRI %
Polychaeta	10.96	34.50	8.21	661.52	7.21
Crustacea					
Cladocera	2.80	9.17	0.12	26.76	0.29
Ostracoda	2.50	9.61	0.97	33.35	0.36
Copepoda	4.42	17.03	1.41	99.26	1.08
Mysidacea	43.19	76.86	21.85	4998.92	54.45
Amphipoda	15.67	44.10	15.21	1362.23	14.84
Brachyura	2.35	8.73	1.22	31.20	0.34
Decapoda	10.89	43.23	16.01	1163.03	12.67
Mollusca					
Bivalvia	1.62	6.11	2.43	24.75	0.27
Chaetognatha					
Sagitta sp.	1.62	6.55	0.87	16.30	0.18
Teleostei	3.97	21.40	31.69	763.16	8.31

Table 5: Index of relative importance (%IRI) in prey groups by seasons for *Arnoglossus laterna* (N: number of fish; TL: total length of fish; SD = Standard deviation)

	Spring	Summer	Autumn	Winter
N	134.00	145.00	131.00	130.00
Mean $TL_{(cm)}$	10.80	11.20	10.60	11.50
SD	2.14	1.98	1.75	2.07
Prey groups				
Polychaeta	8.97	10.07	2.23	8.83
Crustacea				
Cladocera			0.43	1.75
Ostracoda	0.11	0.21	0.51	0.63
Copepoda	0.21	0.73	1.42	2.06
Mysidacea	67.96	62.08	50.49	31.16
Amphipoda	11.68	14.58	12.98	15.83
Brachyura			0.57	2.05
Decapoda	10.41	11.11	15.11	12.61
Mollusca				
Bivalvia	0.03	0.08	0.94	0.30
Chaetognatha				
Sagitta sp.	0.01		0.36	0.52
Teleostei	0.62	1.14	14.97	24.27

There were some fluctuations in the feeding intensity throughout the ages. According to the examination of diet composition related to ages, two groups were formed by IRI percentage of food items (Fig. 2). IRI % composition of preys ranged between 3.2 and 91.0 for I and II age groups, with a prey diversity increasing for those larger than III ages, primarily due to a diet shift to teleost larvae, which may be associated with the variations of the prey availability in the feeding ground and of the proportion of each length group in the population in each particular sampling period. The fluctuations shown by immatures can be caused by the fact that they can consume smaller preys as their mouth entrance is smaller (Cailliet, 1977 in Avsar, 1994; Sanchez-Velasco, 1998) and these small preys, e.g., copepods, amphipods, mysids, are probably digested much more rapidly than the larger one.

Avsar (1994) found in Mersin Bay that; crustaceans forms the main prey, followed by teleosts, polychaetes, nematods and molluscs. De-Groot (1971) studied the interrelationship between the morphology of the alimentary track, the type of food, the feeding behavior and especially diurnal nourishment in flatfish. And identified scaldfish obtained from North Sea mostly as crustacean feeders and reported that scaldfish feed also on small fish. Similarly, Gibson and Ezzi (1987) stated that this carnivorous species predates also small bottom invertebrates; mainly Decapoda, Mysidacea and Polychaeta across the west coast of Scotland. Also, other studies on diet composition of the species (de Morais and Bodiou, 1984; Piet *et al*., 1998; Darnaude *et al*., 2001; Cabral *et al*., 2002; Cartes *et al*., 2002) reported that *A. laterna* feeds on zoobenthos and fish.

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