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Length-Weight Relationships of Fishes from Gökova Bay, Turkey (Aegean Sea)

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Abstract: Length-weight relationships (LWRs) are presented for 17 fish species caught from Gökova Bay (southeastern Aegean Sea) during the 2006 fishing season. Fish samples were collected from small-scale trammel nets and longline fisheries. The values of b ranged from 2.086 (±0.152) for *Sphyraena sphyraena* to 3.499 (±0.058) for *Scomber japonicus*. The median value of b was 3.055 (±0.081). The r^2 values ranged from 0.712 for *Sphyraena chrysotaenia* to 0.996 for *Scomber japonicus* and all relationships were highly significant ($P < 0.001$). Estimated LWR parameters of 4 species, *Dicentrarchus labrax*, *Seriola dumerili*, *Siganus luridus* and *Sphyraena sphyraena*, for Turkish waters are presented for the first time.

Key Words: Length-weight relationship, marine fish, Gökova Bay, Turkey, Aegean Sea

Gökova Körfezi (Ege Denizi) Balıklarının Boy-Ağırlık İlişkileri

Özet: Bu çalışmada, 2006 yılı avcılık sezonu boyunca Gökova Körfezi'nde yakalanan 17 balık türü için boy-ağırlık ilişkileri verilmiştir. Örnekler küçük ölçekli fanyalı ağlar ile paragat balıkçılığından elde edilmiştir. İlişkinin b değeri *Sphyraena sphyraena* için 2,086 (±0,152) ile *Scomber japonicus* için 3,499 (±0,058) arasında değişmektedir ve b'nin ortanca değeri 3,055 (±0,081)'dir. Tanımlayıcılık katsayısı (r^2) değeri *Sphyraena chrysotaenia* için 0,712 ile *Scomber japonicus* için 0,996 olan değerler arasında değişmekte ve tüm ilişkiler istatistiki açıdan oldukça önemlidir ($P < 0,001$). Dört türün (*Dicentrarchus labrax*, *Seriola dumerili*, *Siganus luridus* ve *Sphyraena sphyraena*) boy-ağırlık ilişkileri Türkiye suları için ilk defa verilmiştir.

Anahtar Sözcükler: Boy-ağırlık ilişkisi, deniz balıkları, Gökova Körfezi, Türkiye, Ege Denizi

Introduction

Length-weight relationship (LWR) is important in fisheries science. It is notably used to extrapolate from length-frequency samples to total catch, estimate biomass from underwater length observations, or allow an estimate of the condition of fish. These measurements are also useful for between-region comparisons of life histories of fish species (Froese and Pauly, 2000; Moutopoulos and Stergiou, 2002).

There are many studies on LWR of fish in the Black Sea (Demirhan and Can, 2007), in lakes and lagoons of the Marmara region (Tarkan et al., 2006), the Aegean Sea (Moutopoulos and Stergiou, 2002; Koutrakis and Tsikliras, 2003; Filiz and Bilge, 2004; Karakulak et al., 2006; Özaydın and Taşkavak, 2006; Akyol et al., 2007; İşmen et al., 2007; Özaydın et al., 2007), and the Mediterranean Sea (e.g. Taşkavak and Bilecenoğlu, 2001; Çiçek et al., 2006).

Gökova Bay, with a total area of 52,000 hectares, is located in the connection zone of the Aegean Sea and the Mediterranean and it is one of the 8 marine protected areas in Turkey (Akyol et al., 2007). Furthermore, Gökova Bay is a very important area since it is a nursery ground for many fish species.

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In this study, the parameters of LWRs are reported for 17 fish species, 4 of which are lessepsian immigrants, collected from Gökova Bay.

Materials and Methods

The specimens used in this study were collected from small-scale coastal fisheries, using trammel nets and longlines during 2006 in Gökova Bay. Scientific names for each species are given according to Froese and Pauly (2007). Specimens were measured to the centimeter (±0.1 cm) fork length (FL) or total length (TL) and body weight (W) was also recorded in grams (±0.1 g).

The parameters *a* and *b* of relationships of the equation:

$W = a L^b$,

which is estimated through logarithmic transformation:

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

where W is weight (g), L is length (cm), *a* is the intercept and *b* is the slope of the linear regressions. The obtained coefficients were analyzed with ANOVA (Zar, 1996). The degree of relationship between the variables was computed by the determination coefficient, r^2. The null hypothesis of isometric growth (H_0: b = 3) was tested by *t*-test, using the statistic: $t_s = (b-3)/S_b$, where Sb is the standard error of the slope for $\alpha = 0.05$ (Sokal and Rohlf, 1987). All calculations were performed using the Statistica 6.0 software package.

Results and Discussion

The sample size, minimum, maximum, and mean lengths (±SE, standard error) for each species, the parameters *a* and *b* of the LWRs, the SE of *b* and the coefficient of determination r^2 are presented in the Table. *Scomber japonicus* is a cosmopolitan species; *Diplodus sargus* is a Mediterranean endemic; 4 species, *Siganus luridus, S. rivulatus, Sphyraena chrysotaenia,* and *Upeneus molluccensis* are lessepsian immigrants, and the rest are Atlanto-Mediterranean origin (Bilecenoğlu et al., 2002). Out of the 17 listed in the Table, LWRs have been published for 8 species for Gökova Bay (*Diplodus annularis, D. vulgaris, Epinephelus aeneus, E. costae, Lithognathus mormyrus, Pagellus erythrinus, Sparus aurata, Saurida undosquamis;* (see Akyol et al., 2007). These species caught by longline fishery in the same area were added to the bottom of the Table. Although the number of samples was 8, LWR of *D. maroccanus* was computed because there is no LWR data of this species in Fishbase for eastern Mediterranean.

The values of *b* ranged from 2.086 (±0.152) for *S. sphyraena* to 3.499 (±0.058) for *S. japonicus*. The median value of *b* was 3.055 (±0.081) (Figure). The exponent *b* was often close to 3. Concerning the type of growth, isometric growth in 8, negative allometry in 4, and positive allometry in 5 species were obtained. The r^2 values ranged from 0.712, for *S. chrysotaenia,* to 0.996, for *S. japonicus*, and all relationships were highly significant ($P < 0.001$). The estimates of LWR parameters of 4 species, *Dicentrarchus labrax, Seriola dumerili, Siganus luridus,* and *Sphyraena sphyraena* are presented for the first time for Turkish waters.

Fish samples in this study were intermittently collected throughout the year. So, the data are not representative of a particular season and thus estimated parameters of LWR should be considered as mean annual values. In addition, Froese (2006) stated that small specimens have a different LWR from larger specimens. Due to size selection properties of the trammel nets and longlines used during the study, our fish samples do not include small sized individuals for all the species.

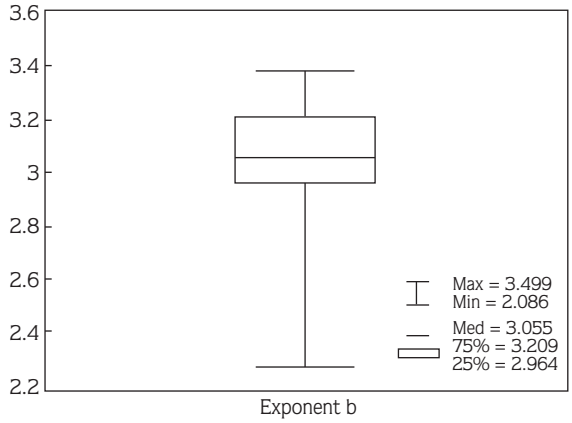

Figure. Box-whisker plots of the exponent *b* of the LWR for 17 fish species of the Gökova Bay, Turkey.

Table. Following are the descriptive statistics and estimated parameters of the LWR for fish species caught from small-scale fisheries in Gökova Bay (southeastern Aegean Sea). TL = total length, FL = fork length, N = sample size, SE = standard error, r^2 = coefficient of determination, a = intercept, b = slope of the linear regressions, GT = growth type.

Species	Length characteristics (cm)						Parameters of LWR				GT
	Origin	Length	N	Mean	SE	Range	*a*	*b*	SE(*b*)	r^2	
Boops boops (Linnaeus, 1758)	A-M	TL	32	21.4	0.51	16.5 – 27.0	0.0085	3.092	0.137	0.945	0
Dentex dentex (Linnaeus, 1758)	A-M	TL	39	23.5	0.84	15.0 – 36.5	0.0105	3.055	0.081	0.975	0
Dentex maroccanus (Valenciennes, 1830)	A-M	TL	8	18.0	0.93	14.8 – 21.8	0.1186	2.287	0.304	0.904	-
Dicentrarchus labrax (Linnaeus, 1758)	A-M	TL	28	36.9	1.75	24.5 – 59.0	0.0359	2.676	0.107	0.960	-
Diplodus sargus (Linnaeus, 1758)	M	TL	33	21.3	0.74	16.0 – 32.3	0.0144	3.061	0.079	0.980	0
Merluccius merluccius (Linnaeus, 1758)	A-M	TL	21	28.1	1.17	21.5 – 40.5	0.0061	3.036	0.170	0.944	0
Mullus surmuletus (Linnaeus, 1758)	A-M	TL	120	17.2	0.16	13.1 – 25.1	0.0069	3.214	0.044	0.979	+
Pagellus acarne (Risso, 1827)	A-M	FL	46	14.1	0.17	12.1 – 16.5	0.0094	3.265	0.110	0.952	+
Sarpa salpa (Linnaeus, 1758)	A-M	FL	77	18.2	0.26	14.0 – 23.2	0.0102	3.209	0.103	0.929	+
Scomber japonicus (Houttuyn, 1782)	C	FL	16	26.7	1.08	20.5 – 33.0	0.0024	3.499	0.058	0.996	+
Seriola dumerili (Risso, 1810)	A-M	FL	14	24.1	0.39	22.0 – 27.0	0.0199	2.964	0.165	0.964	0
Siganus luridus (Rüppell, 1829)	R	TL	22	16.5	0.41	13.2 – 20.8	0.0172	2.983	0.134	0.961	0
Siganus rivulatus (Forsskål, 1775)	R	TL	56	16.2	0.29	11.7 – 23.0	0.0088	3.112	0.155	0.882	0
Sphyraena chrysotaenia (Klunzinger, 1884)	R	FL	57	21.9	0.19	19.2 – 25.0	0.0062	3.038	0.108	0.936	0
Sphyraena sphyraena (Linnaeus, 1758)	A-M	FL	78	27.1	0.19	21.0 – 32.6	0.0942	2.086	0.152	0.712	-
Trachurus mediterraneus (Steindachner, 1868)	A-M	FL	45	22.7	0.79	16.5 – 38.3	0.0042	3.374	0.102	0.963	+
Upeneus molluccensis (Bleeker, 1855)	R	FL	51	12.7	0.15	10.0 – 17.6	0.0302	2.782	0.110	0.929	-
Diplodus annularis (Linnaeus, 1758)*	A-M	TL	159	14.8	0.19	09.5 – 19.0	0.0179	2.985	0.041	0.971	0
Diplodus vulgaris (Geoffroy Saint-Hilaire, 1817)*	A-M	TL	69	19.2	0.52	09.6 – 26.5	0.0145	3.034	0.041	0.988	0
Epinephelus aeneus (Geoffroy Saint-Hilaire, 1817)*	A-M	TL	36	21.0	0.45	16.0 – 27.8	0.0098	3.043	0.117	0.952	0
Epinephelus costae (Steindachner, 1878)*	A-M	TL	365	18.9	0.15	12.0 – 30.0	0.0176	2.885	0.038	0.942	-
Lithognathus mormyrus (Linnaeus, 1758)*	A-M	TL	141	23.7	0.35	14.5 – 32.6	0.0122	3.034	0.047	0.967	0
Pagellus erythrinus (Linnaeus, 1758)*	A-M	TL	125	30.9	0.48	18.6 – 56.6	0.0178	2.855	0.064	0.942	-
Sparus aurata (Linnaeus, 1758)*	A-M	TL	59	26.7	0.74	14.6 – 45.0	0.0266	2.736	0.068	0.966	-
Saurida undosquamis (Richardson, 1848)*	R	TL	80	26.1	0.36	19.6 – 33.1	0.0046	3.109	0.080	0.951	+

* from Akyol et al. 2007; A-M = Atlanto-Mediterranean, M = Mediterranean endemic, C = Cosmopolitan, R = Lessepsian (Red Sea) immigrant

0= Isometry, += Positive allometry, -= Negative allometry

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