E.Ü. Su Ürünleri Dergisi 2002
E.U. Journal of Fisheries & Aquatic Sciences 2002
Cilt/Volume 19, Sayı/Issue (3-4): 401 – 409

ISSN 1300 - 1590
http://jfas.ege.edu.tr/

A Preliminary Study on Length-Weight Relationships for Seven Elasmobranch Species from North Aegean Sea, Turkey

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Özet: ***Kuzey Ege'de yedi Elasmobranş türünün boy-ağırlık ilişkileri.*** Bu çalışmada, Kuzey Ege Denizi'nden örneklenen yedi elasmobranş türünün boy-ağırlık ilişkileri incelenmiştir. WT= a(TL)^b, şeklinde ifade edilen denklem her tür için hesaplanmıştır. Bu denklem, *Scyliorhinus canicula* için, WT= 0.0016TL$^{3.1804}$ (r^2= 0.9795), *Mustelus mustelus* için, WT= 0.0008TL$^{3.3259}$ (r^2= 0.9745), *Squalus acanthias* için, WT= 0.0031TL$^{3.1056}$ (r^2= 0.9814), *Torpedo marmorata* için, WT= 0.0488TL$^{2.6935}$ (r^2= 0.9584), *Raja. clavata* için, WT= 0.0016TL$^{3.2914}$ (r^2= 0.9337), *Dasyatis pastinaca* için, WT= 0.0085TL$^{2.9379}$ (r^2= 0.9687) ve *Raja miraletus* için, WT= 0.0001TL$^{4.0173}$ (r^2= 0.9251) olarak bulunmuştur. Ayrıca bu denklem her iki eşey için de hesaplanmıştır. Türlerin Min., Maks. ve Ortalama boyları ile ağırlıkları tablolar halinde sunulmuştur.

Anahtar Kelimeler: Boy-ağırlık ilişkisi; Elasmobranchii, Ege Denizi

Abstract: In this study, length-weight relationships of seven elasmobranch species sampled from North Aegean Sea are examined. An equation expressed as WT= a(TL)^b was calculated for each species. It was calculated as WT= 0.0016TL$^{3.1804}$ (r^2= 0.9795) for *Scyliorhinus canicula*, WT= 0.0008TL$^{3.3259}$ (r^2= 0.9745) for *Mustelus mustelus*, WT= 0.0031TL$^{3.1056}$ (r^2= 0.9814) for *Squalus acanthias*, WT= 0.0488TL$^{2.6935}$ (r^2= 0.9584) for *Torpedo marmorata*, WT= 0.0016TL$^{3.2914}$ (r^2= 0.9337) for *Raja. clavata*, WT= 0.0085TL$^{2.9379}$ (r^2= 0.9687) for *Dasyatis pastinaca*, and WT= 0.0001TL$^{4.0173}$ (r^2= 0.9251) for *Raja miraletus*. In addition, this equation was determined for both sexes. Lengths and weights of species (mean, maximum and minimum) were given in Tables.

Key Words: Length-weight relationship; Elasmobranchii; Aegean Sea.

Introduction

Throghout their evolutionary history during at least 400 million years, the cartilaginous fishes (Chondrichthyes) in general have remained major components of marine communities, having the ability to adapt varying selective pressures (Cortes, 2000). Elasmobranch fishes comprise 700-800 species occupying a wide range of habitats distributed throughout the oceans of the world (Frisk *et al*., 2001). Increased human exploitation over the last 2 decades, the biological features (e.g., slow growth and late sexual maturation, very low egg production and long reproductive cycles), and increasing habitat deterioration have threaten to elasmobranch population worlwide (Cortes, 2000; Ellis *et al*., 2002; Heessen, 2002; Prince, 2002). More than 700 000 t of cartilaginous fish have been harvested annually worldwide (Bonfil, 1994; Frisk *et al*., 2001). Harvesting amount in Turkey is 2115 t (0.4% of total marine fishes production) (Filiz and Togulga, 2002). It is reported that there are 64 elasmobranch species in Turkey's waters (Bilecenoğlu *et al*., 2002). Although Turkey has got productive marine resources, researches and education activities regarding marine resources have started in a recent time. Fish stocks are over exploited by fishermen because of many basic objects are not researched. Thus, the feature of stocks will be getting endangered (Samsun *et al*., 1995). Basic biological data needed for stock assessment are scarce for many elasmobranch species (Cailliet and Bedford, 1983; Cailliet *et al*., 1991; Bonfil, 1994), as also existed in Turkey's waters, including size values (i.e. minimum, maximum, and mean) and size relationships/conversions (i.e. length-to-weight). These data are essential for understanding growth rate, age structure and other aspects of population dynamics (Kohler *et al*., 1996).

This study, carried out between the period of July-1999/March-2000, is a preliminary investigation on morphology, biology and zoogeographical distribution of some cartilaginous fish species obtained from North Aegean Sea. In response to the immediate needs for management initiatives, we present length and weight data for the following seven dominant species (*Scyliorhinus canicula* Linnaeus., 1758, *Squalus acanthias* L., 1758, *Mustelus mustelus* L., 1758, *R. clavata* L., 1758, *T. marmorata* Risso, 1810, *D. pastinaca* L., 1758,and *R. miraletus* L., 1758).

Materials and Methods

During the study, a total of 13 species were obtained, comprising 5 shark species; *Heptranchias perlo* (Bonnaterre, 1788), *Scyliorhinus canicula*, *S. stellaris* (L., 1758), *Mustelus mustelus*, *Squalus acanthias* and 8 ray species; *Torpedo marmorata*, *Raja miraletus*, *R. clavata*, *R. oxyrinchus* (L., 1758), *R. radula* (Delaroche, 1809), *Dasyatis pastinaca*, *Gymnura altavela* (L., 1758), *Myliobatis aquila* (L., 1758). A total of 247 samples representing 7 dominant species (comprising 3 shark species; *S. canicula*, *M. mustelus*, *S. acanthias*, and 4 ray species; *T. marmorata*, *R. clavata*, *D. pastinaca*, *R. miraletus*) were measured, sexed, and weighed.

Length and weight data were collected from elasmobranch species caught by commercial fishermen and biologists from the North Aegean Sea during July-1999/March-2000 (Figure 1). Samples were caught by bottom trawl owned by research vessel (RV Egesuf) and commercial fishing boats. The fish were stored in ice until returned to the laboratory, where the length and weight measurements were taken after the fish were thawed ice.

All lengths were taken with a metal measuring tape nearest to centimeter in a straight line along the body axis with the caudal fin placed in a natural position. Total length (TL) is defined as the distance from the tip of the snout to the end of the upper caudal lobe.

Total weight (WT) of each specimens was measured as gram.

Generally, length-weight relationship in fish is demonstrated as an exponential relation (Tıraşın, 1993). The form of the equation is:

$$(WT) = a\,(TL)^b$$

where, WT, is total weight (g), TL, is total length (cm), and a and b are constants for each species. Length-weight relationships, mean lengths and weights, and size ranges were determined for 7 elasmobranch species (n=247).

Results and Discussion

Minimum, maximum and mean lengths and weights of the species examined are given in Tables 1 and 2.

In order to see the significant differences in slope or intercept of the length-weight relationships among male-female, only male, and only female, we calculated one equation to represent data for each species (Figures 2–8). Mollet and Cailliet (1996) noted that the allometric size-on-size equation y = ax^b (power function) has rarely been used to report elasmobranch morphometry (except for reporting length-weight relationships) and, however, it would be the most suitable equation for characterizing allometry.

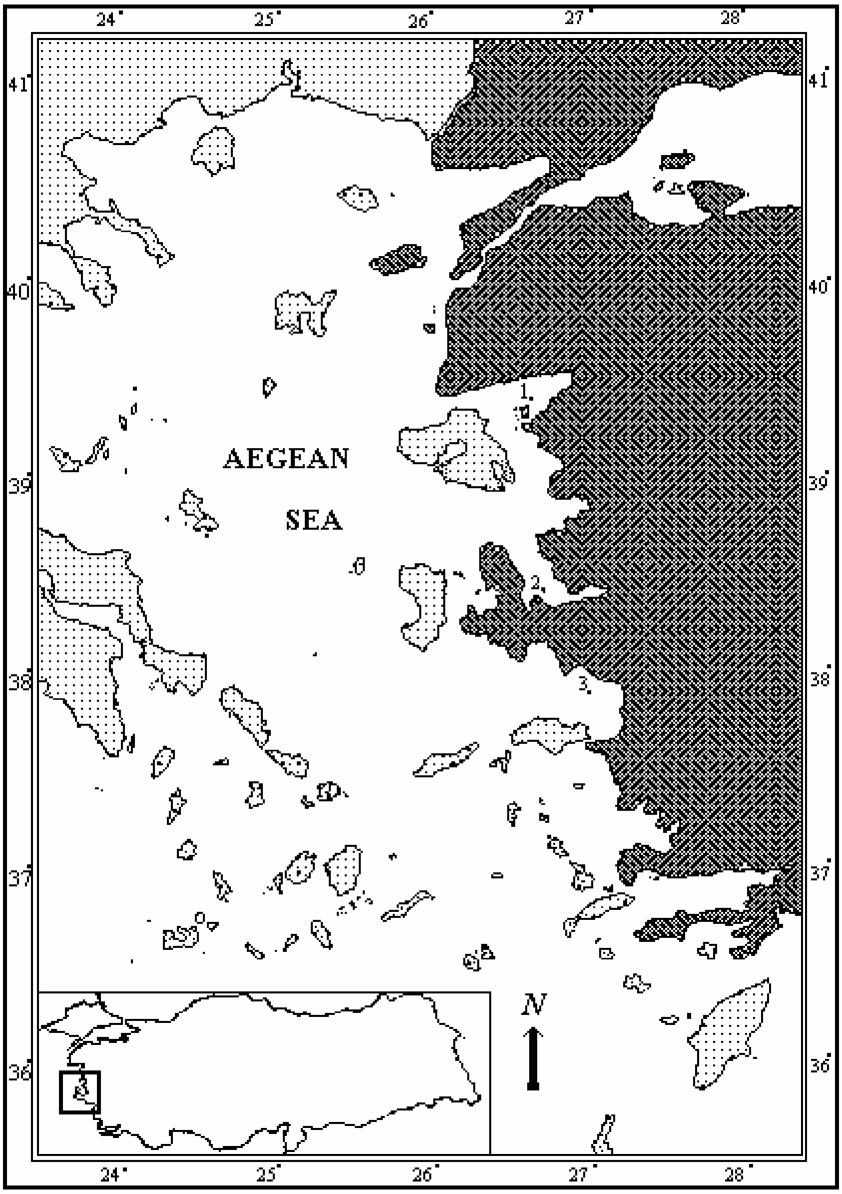

Figure 1. Study areas: Edremit Bay (1), Gulbahce Bay (2), and Sigacik Bay (3).

Table 1. Min., max., and mean lengths of the examined species (CI: confidence interval, C: sexes combined, M: male, and F: female)

Species	Sex	N	Mean±CI	Min.	Max.	Std. Dev.
	C	113	36.56±1.62	17.50	52.50	8.80
S. canicula	M	49	40.37±2.16	24.00	52.50	7.73
	F	64	33.65±2.08	21.50	49.40	8.50
	C	24	62.02±7.25	38.30	97.50	18.12
M. mustelus	M	14	57.71±8.25	38.30	85.20	15.74
	F	10	68.06±12.58	44.00	97.50	20.30
	C	32	53.64±3.87	27.00	70.50	11.18
S. acanthias	M	16	47.81±2.87	38.00	56.50	5.86
	F	16	59.47±6.03	27.00	70.50	12.30
	C	20	15.78±1.91	9.60	25.00	4.35
T. marmorata	M	9	15.71±2.57	9.60	20.50	3.93
	F	11	15.83±2.87	11.00	25.00	4.86
	C	31	52.65±6.25	20.50	99.00	17.75
R. clavata	M	8	51.31±8.66	29.70	67.00	12.50
	F	23	53.12±7.95	20.50	99.00	19.46
	C	14	53.39±6.58	40.00	74.20	12.56
D. pastinaca	M	8	54.59±9.56	40.00	74.20	13.80
	F	6	51.78±9.40	40.30	68.00	11.75
R. mirelatus	C	13	45.04±4.26	30.00	56.50	7.84

Table 2. Min., max., and mean weights of the examined species (CI: confidence interval, C: sexes combined, M: male, and F: female)

Species	Sex	N	Mean±CI	Min.	Max.	Std. Dev.
	C	113	184.87±22.79	15.76	473.19	123.58
S. canicula	M	49	238.69±34.79	40.10	473.19	124.26
	F	64	143.67±26.17	15.76	409.00	106.81
	C	24	937.07±345.83	116.37	3170.00	864.41
M. mustelus	M	14	734.09±366.05	116.37	1988.00	698.81
	F	10	1221.26±635.20	200.00	3170.00	1024.85
	C	32	833.55±172.90	79.64	1790.14	499.02
S. acanthias	M	16	529.84±86.49	233.14	783.86	176.51
	F	16	1137.25±262.38	79.64	1790.14	535.47
	C	20	98.65±35.85	23.51	340.00	81.79
T. marmorata	M	9	84.05±31.58	23.51	156.94	48.34
	F	11	110.59±60.53	27.15	340.00	102.43
	C	31	1029.74±282.69	28.86	2614.28	803.05
R. clavata	M	8	895.56±425.44	94.36	1934.80	613.96
	F	23	1076.41±354.08	28.86	2614.28	866.40
	C	14	1172.64±414.57	387.83	2955.00	791.44
D. pastinaca	M	8	1338.41±639.10	387.83	2955.00	922.29
	F	6	951.62±463.21	392.42	1750.00	578.90
R. miraletus	C	13	620.77±172.42	100.01	1000.54	317.19

S. canicula exhibited "positive allometric growth" (Fig. 2a). The functional regression b values for each sex and the pooled data were found to be bigger than "3" (Figs. 2a, b, and c). Using the coefficient of the length-weight relationship for each sex, it can be stated that lesser spotted dogfish weight increases rapidly with growth. The length-weight relationship of lesser spotted dogfish from North Aegean Sea is similar to the data calculated by Oray (1989) for Aegean Sea (a= 0,002193, b= 3,094561, and r= 0,9669), Cihangir *et al.* (1997) for North Aegean Sea (a= 0,01, b= 3,205, and r= 0,919), Froese and Pauly (2000) for Bay of Biscay (a= 0,0038, b= 3,029; a= 0.0031), East and West Channel, France (a= 0.0031, b= 3.029, and r= 0.985), and Balearic Islands, Spain (a= 0.0016, b= 3.16, and r= 0.993).

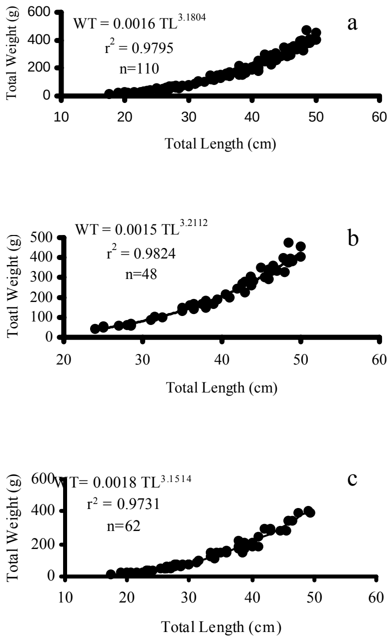

Figure 2. Relationship between total length and total body weight for the lesser spotted dogfish (*S. canicula*); male-female (a), male (b), and female (c).

M. mustelus exhibited "positive allometric growth" (Fig. 3a). The functional regression b values for each sex and the pooled data were found to be bigger than "3" (Figs. 3a, b, and c) Using the coefficient of the length-weight relationship for each sex, it can be stated that smooth-hound dogfish weight increases rapidly with growth. In spite of our extreme endeavors and efforts, unfortunately we couldn't find any study to confirm this information.

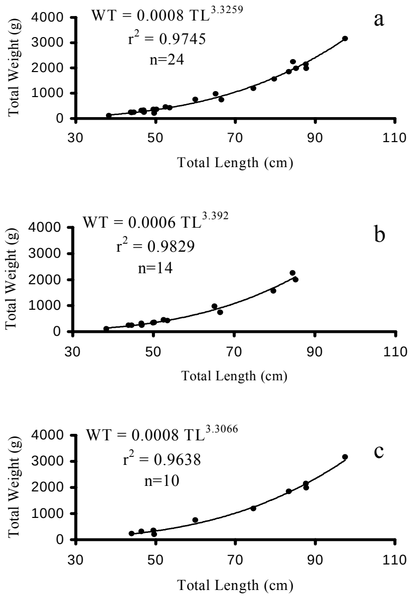

Figure 3. Relationship between total length and total body weight for the smooth-hound dogfish (*M. mustelus*); male-female (a), male (b), and female (c).

S. acanthias exhibited "positive allometric growth" (Fig. 4a). From the coefficient of the length-weight relationship for spiny dogfish, it is seen that its weight inceases rapidly with growth. The length-weight relationship constants of spiny dogfish from North Aegean Sea are similar to the data given by Jones and Geen (1977) for the Strait of Georgia, British Columbia (a= 0.0017 and b= 3.47), Kutaygil and Bilecik (1998) for SW Black Sea coast (a= 0.027 and b= 3.02), and Froese and Pauly (2003) for North Puget Sound, USA (a= 0.004 and b= 3.004) and South Africa (a= 0.0015 and b= 3.22). However, the "b" value given by Avsar (1996) and (2001) as W= $0.0040L^{2.95}$ for southeastern Black Sea was smaller than this in the present study (b= 3.1056). The reason of this difference was explained by the investigator as; "*this may be due to differences in sampling times of the studies reflecting inter-population variation*". In addition, according to Avsar (2001), "*the functional regression b-values for males, females and the pooled data were found to be smaller than '3' (intercepts: 0.0045, 0.0035, 0.0040; slopes: 2.92, 2.99, 2.95; coefficients=0.987; 0.993, 0.988, respectively). While the confidence intervals for the b-values of males (2.87-2.97), females (2.90-3.08) and the pooled data (2.92-2.98) implies that the body shape of the females displays both of negative and positive allometric growth characteristics, the males and sexes combined show negative allometric form*". Comparing values of "b" coefficient, the weights in females increase faster in relation to length than those in males (Figs. 4b, and c). A similar situation is reported by Samsun *et al.* (1995), Avsar (1996, 2001) and Froese and Pauly (2003), whereas Kutaygil and Bilecik (1998) reported the "b" values for males and females as 3.0046 and 2.9294, respectively. Soldat (2002) also reported "positive allometric growth" both males and females (b= 3.955 and 3.148, respectively).

T. marmorata exhibited "negative allometric growth" (Fig. 5a). The functional regression b values for each sex and the pooled data were found to be smaller than "3" (Figs. 5a, b, and c). But, no study was found to confirm this information.

R. clavata exhibited "positive allometric growth" (Fig. 6a). The functional regression b values for each sex and the pooled data were found to be bigger than "3"(Figs. 6a, b, and c). The length-weight relationship of thornback ray from North Aegean Sea is similar to the data given by Düzgüneş *et al.* (1999) for East Black Sea (a= 0.003, b= 3.1841 and r= 0.9954), Froese and Pauly (2000) for Bay of Biscay, France (a= 0.00324 and b= 3.201), and Erdem *et al.* (2001) for Sinop coast, Black Sea (a= 0.0026, b= 3.1980 and r^2= 0.98).

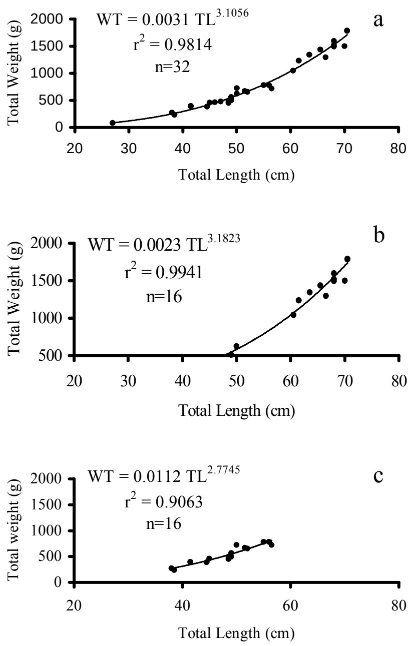

Figure 4. Relationship between total length and total body weight for the spiny dogfish (*S. acanthias*); male-female (a), male (b), and female (c).

D. pastinaca exhibited "negative allometric growth" (Fig. 7a). The functional regression b values for each sex and the pooled data were found to be smaller than "3" (Figs. 7a, b, and c). However, the length-weight relationship constants given by Froese and Pauly (2000) for South Africa (a= 0.0251, b= 3.11) are higher than those obtained in the present study. Ismen (2003) also found that the functional regression b-values for pooled data, males and females were higher than "3" for eastern Mediterranean (intercepts: 0.00144, 0.00237, 0.00091; slopes: 3.31, 3.17, 3.44; correlation coefficients= not given, 0.95, 0.94). This may be due to differences in sampling times of the studies reflecting variation in food availability or differences in water temparatures for both regions.

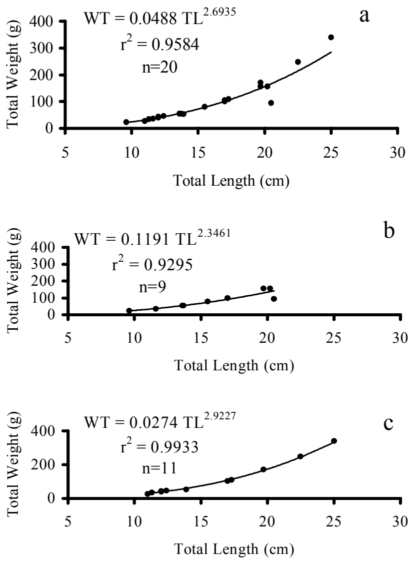

Figure 5. Relationship between total length and total body weight for the common crampfish (*T. marmorata*); male-female (a), male (b), and female (c).

R. miraletus exhibited "positive allometric growth" (Fig. 8). The functional regression b values for pooled data were found to be bigger than "3". Our "b" value (4.0173) is bigger than calculated by Froese and Pauly (2000) for Balearic Islands, Spain (a= 0.0018, and b= 3.25). This may be due to less sample size.

As a result of the study, it is seen that some species (*S. canicula*, *M. mustelus, S. acanthias, R. clavata* and *R. miraletus*) exhibit "positive allometric growth", while others (*T. marmorata* and *D. pastinaca*) have "negative allometric growth". The difference between "b" values of males (b= 2.7745) and females (b= 3.1823) was found only in *S. acanthias*.

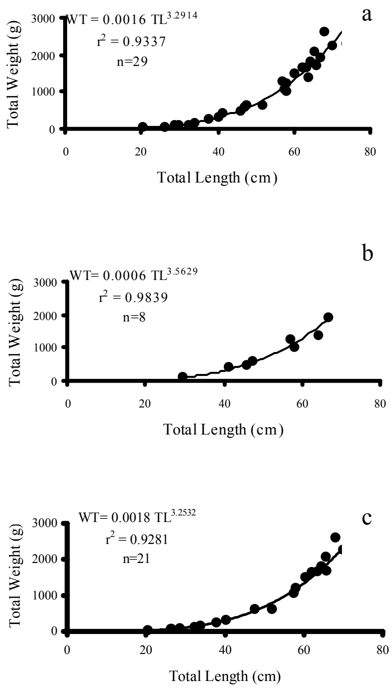

Figure 6. Relationship between total length and total body weight for the thornback ray (*R. clavata*); male-female (a), male (b), and female (c)

Some inconsistent results may be come out because of difficulties to obtain sufficient specimen in all size classes. More extensive sampling sizes over a wider geographical range, almost equal representation of sexes, and more detailed demographic analyses including age, growth, and reproduction, is a must to be taken into consideration before certain definities of the life history of these seven species. Studies of length-weight relationships of these species in the present paper provide comparative information on these parameters for elasmobranchs existed different parts of Turkey's waters.

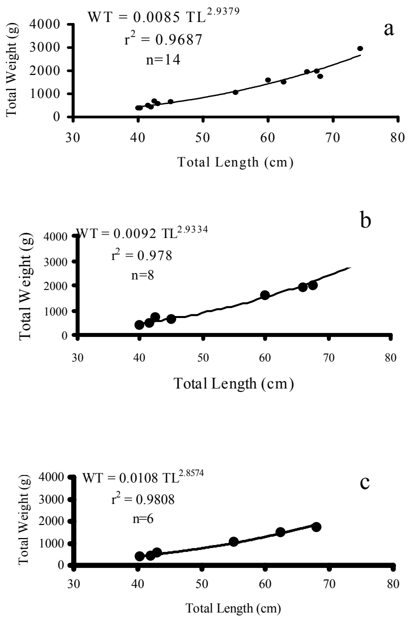

Figure 7. Relationship between total length and total body weight for the common stingray (*D. pastinaca*); male-female (a), male (b), and female (c).

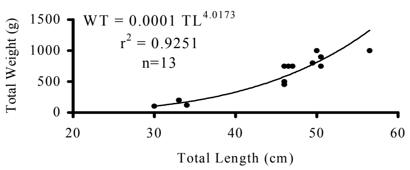

Figure 8. Relationship between total length and total body weight (sexes combined) for the brown ray (*R. miraletus*).

Acknowledgments

No data could have been collected without helps and cooperations of fishermen who allowed us to their ships. The scientists and crew of RV Egesuf also assisted in obtaining specimens during sampling cruises. We would like to thank to Ertan Taskavak, Okan Ozaydın and Murat Bilecenoglu for their assistance and support.

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