American Fisheries Society Symposium 63:xxx, 2008

Length-weight Relationships of Three Macrourid Fishes in the Eastern Aegean Sea, Turkey

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Abstract.—Length–weight relationships of three macrourid fishes (saddled grenadier *Caelorinchus caelorhincus*, glasshead grenadier *Hymenocephalus italicus* and bluntsnout grenadier *Nezumia sclerorhynchus*) from Sigacik Bay on the Turkish coast of the Aegean Sea are presented. Overall, 923 specimens of three different species of the family Macrouridae were weighed and measured. The sample size ranged from 43 for bluntsnout grenadier to 782 for saddled grenadier. The values of the exponent *b* in the length–weight regressions ($W=aL^b$) varied between 2.51 (saddled grenadier) and 3.49 (bluntsnout grenadier). Regressions of length–weight relationships were significant for all species. Positive allometry in weight vs. length for bluntsnout grenadier, isometry in saddled grenadier, and negative allometry for glasshead grenadier were observed.

Introduction

The deep-sea fish fauna of the eastern Aegean Sea has been poorly studied and very little biological information is available (e.g., Filiz and Bilge 2004; Filiz et al. 2006). The same is true for the macrourid fishes inhabiting Turkish seas because of their low economic importance and the poor development of a deep-sea trawl fishery in the area.

Length–weight relationships are used to provide information on the condition of fish (Le Cren 1951; Tesch 1971). They are important because they allow: (a) an estimate of the condition of fish; (b) estimation of biomass from length observations; (c) conversion of growth-in-length equations to growth-in-weight; and (d) useful between-region comparisons of life histories of species (Pauly 1993; Gonçalves et al. 1996; Binohlan and Pauly 1998). These relationships may also help to determine whether somatic growth is isometric or allometric (Ricker 1975).

Length–weight relationships for saddled grenadier *Caelorinchus caelorhincus* were given by Borges et al. (2003) and Morey et al. (2003) from the western Mediterranean. Morey et al. (2003) also gave the length–weight relationship for glasshead grenadier *Hymenocephalus italicus*. A review of the current literature indicated that little is known about biology and growth rate of the macrourid fishes in the Mediterranean basin. For Turkish waters, length-weight relationship data are given only for saddled grenadier (Filiz and Bilge 2004; Filiz et al. 2006). In addition, to the best of our knowledge, no information currently exists on the length-weight relationships of glasshead grenadier and bluntsnout grenadier *Nezumia sclerorhynchus* in the eastern Mediterranean Sea.

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The aim of the present work is to contribute towards the knowledge of isometric or allometric growth based on the length-weight relationships of three macrourid deep water fishes of the eastern Aegean Sea for which biological data are rather scarce and incomplete in the eastern Mediterranean.

Methods

We sampled macrourid fishes on board a 23-m commercial fishing vessel (F/V Hapuloglu) from March 2002 to July 2006 in Sigacik Bay, Aegean Sea (37°54'N, 26°56'E and 38°08'N, 26°42'E). A total of 26 hauls were carried out at depths ranging from 200 to 600 m. A typical Mediterranean deep trawl net of 6 mm cod end mesh size was used and the average duration of each haul was about three hours. Samples collected from each haul were put in labeled 5 L plastic containers and preserved in 4% of formaldehyde solution. Length and weight measurements were recorded in the laboratory to the nearest mm (using a measuring board) and the nearest g (using a digital balance), respectively. Fishes were identified based on Fisher et al. (1987), and scientific names were checked with FishBase (Froese and Pauly 2006).

Length-to-weight relationship for total body weight was calculated using the equation $W = aL^b$, where W is total weight, L the total length (TL), a the intercept, and b the slope. The degree of association between the variables was computed by the determination coefficient r^2. The parameters a and b were estimated by linear regression on the log-transformed (Log_{10}) equation $log(W) = log\ (a) + b\ log\ (L)$. The significance of the regression was assessed by analysis of variance (ANOVA), and the b-value for each species was tested by t-test to verify that it was significantly different from the predictions for isometric growth ($b = 3$).

Results and Discussion

Overall, 923 specimens of three different species of the family Macrouridae were weighed and measured to estimate length-weight relationships (Table 1). Relationships (linear regressions) were significant for saddled grenadier and bluntsnout grenadier ($P < 0.001$, with r^2 values being greater than 0.95) but not for the glasshead grenadier ($r^2 = 0.88$ and $P < 0.001$).

Values of b equal to 3 indicate that the fish grows isometrically; values different from 3 indicate allometric growth. The exponent b varied between 2.51 for saddled grenadier and 3.49 for bluntsnout grenadier (Table 1). An over-proportional increase in length relative to growth in weight is reflected in an exponent of $b < 2.5$, or to the contrary, an exponent of $b > 3.5$ indicates an over-proportional increase in weight relative to growth in length (Froese 2006). Concerning growth types, the length–weight relationships revealed that weight increases isometrically with length for saddled grenadier ($p > 0.05$, t_{cal}: 1.67, $t_{0.05(781)}$: 1.98). Positive allometry in bluntsnout grenadier ($p < 0.05$, t_{cal}: 4.58, $t_{0.05(42)}$: 2.02) and negative allometry in glasshead grenadier ($p < 0.05$, t_{cal}: 3.66, $t_{0.05(97)}$: 2.00) were observed. Carlander (1977) demonstrated that values of $b < 2.5$ or >3.5 are often the consequence of small sample sizes. Given the sample sizes in our study, this is unlikely to be the case. However, these variations from isometry may be due to the very small specimens that had not yet reached adult body size but included in the regression.

Other studies conducted in Turkish waters (Filiz and Bilge 2004; Filiz et al. 2006) reported values of the scaling exponent b ranging from 2.74 to 3.01 for the saddled grenadier. Our results are quite similar to those reported by Filiz and Bilge (2004) and Filiz et al. (2006), i.e., isometric growth in spite of limited sample sizes in previous studies (Table 2).

A comparison of published length–weight

Table 1. Descriptive statistics and estimated parameters of the length–weight relationship for three macrourid fishes collected from Sigacik Bay of the eastern Aegean Sea, Turkey. *L*min – *L*max = minimum and maximum lengths (cm); Wmin – Wmax = minimum and maximum weights (g); C.I = confidence intervals; *a* = intercept of the relationship; *b* = slope of the relationship; r^2= coefficient of determination; *N* = sample size.

Species	*N*	*L*min – *L*max	Wmin – Wmax	$W = aL^b$		
		[mean±95%C.I.]	[mean±95%C.I.]	*a*	*b* ± 95% C.I.	r^2
Saddled Grenadier *Coelorinchus coelorinchus* (Risso, 1810)	782	8.70-23.20 [13.97±0.25]	2.98-36.42 [9.53±0.58]	0.0083	2.83±0.26	0.99
Glasshead Grenadier *Hymenocephalus italicus* Giglioli, 1884	98	6.70-16.80 [12.56±0.49]	1.15-10.22 [4.36±0.49]	0.0069	2.51±0.27	0.88
Bluntsnout Grenadier *Nezumia sclerorhynchus* (Valenciennes, 1838)	43	6.00-19.60 [15.58±0.81]	0.34-18.76 [10.23±1.25]	0.0006	3.49±0.22	0.96

Table 2. Comparison of the length-weight relationship parameters. L= lengths, minimum and maximum (cm); *N* = sample size; *a* = intercept of the relationship; *b* = slope of the relationship; r^2 = coefficient of determination ([1]used pre-anal length).

Study	Area	N	*L*min – *L*max	*a*	*b*	r^2
Saddled grenadier *Coelorinchus coelorhincus* (Risso, 1810)						
Diaz et al. (2000)	Colombian Caribbean	251	8.1 – 35.6	0.0004	2.13	-
Borges et al. (2003)	Algarve (southern Portugal)	25	8.6 – 22.0	0.0022	3.11	0.93
Morey et al. (2003)[1]	Western Mediterranean	175	2.1 – 12.3	0.0925	3.14	0.97
Filiz and Bilge (2004)	North Aegean Sea	208	9.0 – 21.6	0.0065	2.74	0.78
Filiz et al. (2006)	North Aegean Sea	411	9.0 – 21.6	0.0032	3.01	0.92
Present study	Eastern Aegean Sea	782	8.70-23.20	0.0083	2.83	0.99
Mean		1852		0.0189	2.83	
Glasshead grenadier *Hymenocephalus italicus* Giglioli, 1884						
Morey et al. (2003)[1]	Western Mediterranean	69	2.2 – 5.1	0.1277	2.80	0.97
Present Study	Eastern Aegean Sea	98	6.70-16.80	0.0069	2.51	0.88
Mean		167		0.0673	2.67	
Bluntsnout grenadier, *Nezumia sclerorhynchus* (Valenciennes, 1838)						
Present Study	Eastern Aegean Sea	43	6.00-19.60	0.0006	3.49	0.96
Mean		43		0.0006	3.49	

relationships for the species is given in Table 2. The values of the slope (*b*) for saddled grenadier ranged from 2.13 to 3.74 and our results remained within the ranges given (Table 2). Except for data reported by Diaz et al. (2000), who computed a scaling exponent of 2.13 and determined an allometric growth for the species from the Colombian Caribbean, our results mostly agreed with the macrourid studies given in Table 2. Mean condition of specimens as well as the difference in condition between small and large specimens vary between seasons, localities and years, resulting in different length–weight relationships (Froese 2006). Length ranges given by Morey et al. (2003) for glasshead grenadier were between 2.2 and 5.1 cm, while they varied between 8.70 and 23.20 cm in this study (Table 2). Since the length ranges and measurement scales in both studies (Morey et al. 2003 used preanal length; the present study used total length) do not overlap, the results are not comparable. For the bluntsnout grenadier, no length–weight relationship information was available in FishBase (Froese and Pauly 2006) or in literature scanned during our study (Table 2).

The length–weight relationship in fishes can be affected by a number of factors, including season, habitat, gonad maturity, sex, diet and stomach fullness, health and preservation techniques, and differences in the length ranges of the specimen caught (Tesch 1971; Wootton 1998), which were not accounted for in the present study. Thus, differences in length-weight relationships between this and other studies could potentially be attributed to the combination of one or more of the factors given above.

The members of the family Macrouridae consistently form an important component of the ichthyofauna of deep-see habitats and are among the most abundant groups in this type of habitat. The family may represent up to 15% of the deep-sea fish population. Except for a very few species (such as roundnose grenadier *Coryphaenoides rupestris,* softhead grenadier *Macrourus berglax,* ridge scaled rattail *M. carinatus* and bigeye grenadier *M. holotrachys,* giant grenadier *Albatrossia pectoralis* and Pacific grenadier *Coryphaenoides acrolepis*), the present economic importance of most grenadiers is minimal, although many species are taken by commercial bottom trawlers as bycatch and discard. Although macrourids are not economically important, they are significant from the aspect of ichthyofauna conservation and overall fish diversity. The present study indicated that more information about the eastern Mediterranean macrourids is required. The information gained in the present survey may enable fish biologists to derive weight estimates for the Sigacik Bay macrourids that are measured but not weighed. Consequently, the data presented here could serve for comparison with similar studies of bays and deep waters of the Mediterranean, and could also be of use when the macrourid populations are subjected to bycatch and discards of commercial fishing, part of recovery programs, or other management and conservation activities.

Acknowledgments

The authors would like to thank A. Kuruca, captain of C/V Kuruca Hapuloglu, and his crew for their assistance in obtaining the fish samples.

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