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Length-Weight Relationships of 21 species of *Elasmobranchii* from Margarita Island, Venezuela

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ABSTRACT:

Length-Weight Relationships (LWR) were estimated for *Elasmobranchii* caught by the artisanal fishing fleet of Margarita Island, Venezuela. A total of 3604 organisms belonging to 21 species (14 sharks and 7 batoids) were analyzed. Growth type, minimum and maximum length and weight are summarized. The estimates for the '*b*' parameter of the LWR ranged between 1.706 and 3.955, with a mean of 3.034. To the best of our knowledge, no information currently exists on the LWR of *Heptranchias perlo, Squalus cubensis, Squatina dumeril, Gymnura micrura*, *Myliobatis freminvillei* and *Mobula hypostoma*. This article stands as a pioneer towards the growth research in these elasmobranchs.

Keywords:
Elasmobranch, shark, batoids, ray, Caribbean.

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INTRODUCTION

The knowledge of how fish grow is essential for stock assessment objectives, since the growth of every single fish is precisely the source of information of every catch obtained by the fishery (Pauly, 1983). Even though there is variation between the weights of organisms of a certain length, the Length-Weight Relationship (LWR) estimates the mean body weight with a high grade of confidence, depending of its coefficient of correlation. LWR could be considered as a trustworthy tool to estimate weight of organisms knowing its length (Cubillos, 2005).

In Venezuela, for *Elasmobranchii*, there are published data of LWR only on *Mustelus higmani* (Etchevers, 1975), *Rhizoprionodon porosus* (Gómez and Bashirulah, 1984), *Carcharhinus limbatus*, *C. perezi, C. falciformis, Gimglymostoma cirratum* (Tavares, 2009) and *Aetobatus narinari* (Tagliafico *et al*., 2012). This work attempts to extend the knowledge of this biological aspect of the commercial elasmobranchii caught in Margarita Island.

MATERIALS AND METHODS

From January 2006 to December 2007, elasmobranches catches landed at three artisan fishing ports of the Margarita Island, Venezuela (Juan Griego, La Pared and El Tirano) and two fishing markets (Los Cocos and Conejeros) were sampled weekly. The specimens were caught by artisanal fishery using surface and bottom gillnets. Detailed descriptions of vessels and fishing gears are accounted by Iriarte (1997) and González *et al*., (2006).

The specimens were identified using descriptions by Compagno (1984) Cervigón and Alcalá (1999) and Compagno *et al.,* (2005). Lengths and weights were obtained by using an ichthyometer (measured to the nearest millimeter) and an electronic balance (measured to the nearest gram), respectively. The total length (TL) was used for all the sharks and some batoids (*Rhinobatos percellens* and *Narcine brasiliensis*); for the rest of the batoids, the disc width (DW) was used (Cervigón and Alcalá, 1999).

The parameters *a* and *b* of LWR were estimated with the statistic program STATGRAPHIC PLUS 5.1, using the potential equation $W=aL^b$; were *W* is the total weight shown in grams, *L* the total length or disc width according to the species shown in centimeters, *a* is the coefficient related with the body shape, and *b* is an exponent related with the type of growth (isometric when is equal to 3, or allometic when is different to 3) (Beverton and Holt, 1996). To determinate if the estimated values of *b* for every LWR were significantly deviated from isometric growth (*b*=3), a student´s t-test was performed.

The slopes and intercepts of the LWR were compared between males and females, and mature and immature with ANOVA; in case of differences, separated relationships by sex or mature state were established, according to the case. For few infrequent species, it was established a unique relationship for males and females, both mature and immature.

RESULTS AND DISCUSSIONS

A total of 3604 organisms belonging to 21 elasmobranchs: 14 sharks (Figure 1) and 7 batoids (Figure 2) were analyzed. Table 1 shows the obtained coefficients of the equations of the LWR of each species. Low number of specimens analyzed can be acceptable for rare species (Froese, 2006), which is the case of *Mobula hypostoma*.

According to Gómez and Bashirulah (1984) significant differences occur in LWR between males (n=136) and females (n=151) for *Rhizoprionodon porosus*. In the present study, there are no differences between sexes (ANOVA, F (1,214), P=0.01657), analyzing a total of 215 organisms (76 females and 139 males). This discrepancies can be due to differences in the period and zones of sampling,

Table 1. Length-Weight Relationships ($W=aL^b$) of 21 species of *Elasmobranchii* caught by the artisanal fishery of Margarita Island, Venezuela.

Family	Species	n	Sex	L(cm)	W (g)	*a*	95% CL *a*	*b*	95% CL *b*	ES (*b*)	r2	Growth type
				Lmin-max	Wmin-max							
Hexanchidae	*Hexanchus nakamurai*	15	F+M	84.6-106.0	1418-5499	0.00005	0.0000 - 0.3717	3.955	1.9904 - 5.9187	0.909	0.77	A (+)
Heptranchidae	*Heptranchias perlo*	21	F	69.6-117.5	0964-4706	0.0005	0.0001 - 0.0028	3.392	3.0196 - 3.7646	0.178	0.97	A (+)
Squalidae	*Squalus cubensis*	86	F+M	38.5-079.3	0255-2750	0.008	0.0021 - 0.0276	2.912	2.5912 - 3.2334	0.162	0.89	I
Squatinidae	*Squatina dumeril*	67	F	29.2-110.4	0177-10744	0.012	0.0029 - 0.0395	2.954	2.6645 - 3.2436	0.145	0.93	I
		23	Mi	62.0-086.4	1389-5188	0.001	0.0002 - 0.0047	3.435	3.1134 - 3.7569	0.155	0.98	A (+)
		190	Mm	79.9-098.0	4423-8902	2.574	0.8432 - 7.8550	1.706	1.4566 - 1.9551	0.127	0.7	A (-)
Triakidae	*Mustelus canis*	75	F+M	67.0-126.0	0851-1397	0.0003	0.0000 - 0.0011	3.589	3.2703 - 3.9072	0.160	0.93	A (+)
	Mustelus higmani	547	F	28.0-088.4	0057-1673	0.006	0.0015 - 0.0043	3.085	2.9540 - 3.2160	0.067	0.89	I
		125	Mi	34.7-053.3	0113-0425	0.001	0.0002 - 0.0038	3.302	2.9603 - 3.6434	0.174	0.86	A (+)
		293	Mm	39.8-058.3	0227-0624	0.18	0.0736 - 0.4392	1.997	1.7778 - 2.2167	0.112	0.72	A (-)
	Mustelus norrisi	730	F	37.2-072.2	0172-1191	0.003	0.0016 - 0.0046	3.082	2.9509 - 3.2136	0.067	0.86	I
		477	M	37.3-059.3	0170-0709	0.009	0.0042 - 0.0181	2.765	2.5780 - 2.9521	0.095	0.8	A (-)
Carcharhinidae	*Carcharhinus acronotus*	14	F+M	52.1-083.7	0425-3260	0.003	0.0001 - 0.0439	3.148	2.4674 - 3.8280	0.312	0.95	I
	Carcharhinus brevipinna	29	F+M	56.7-079.8	1200-3800	0.003	0.0003 - 0.0239	3.181	2.6878 - 3.6732	0.240	0.93	I
	Carcharhinus falciformis	20	F+M	64.3-094.0	1758-4848	0.078	0.0026 - 2.3202	2.385	1.6133 - 3.1567	0.367	0.84	I
	Carcharhinus limbatus	35	F	63.6-096.4	1361-6500	0.001	0.0004 - 0.0045	3.344	3.0764 - 3.6112	0.131	0.98	A (+)
		62	M	54.5-109.6	2098-6600	0.105	0.0439 - 0.2522	2.346	2.1424 - 2.5495	0.102	0.95	A (-)
	Rhizoprionodon lalandii	202	F	38.3-074.1	0170-2041	0.001	0.0004 - 0.0021	3.357	3.1767 - 3.5375	0.092	0.93	A (+)
		143	M	39.0-095.3	0199-4260	0.005	0.0029 - 0.0095	2.944	2.7938 - 3.0891	0.075	0.96	I
	Rhizoprionodon porosus	215	F+M	34.6-106.4	0113-5499	0.002	0.0009 - 0.0024	3.25	3.1305 - 3.3699	0.061	0.96	A (+)
Sphyrnidae	*Sphyrna lewini*	11	F+M	37.2-093.0	0425-4350	0.011	0.0003 - 0.3393	2.789	1.9336 - 3.6451	0.378	0.93	I
Narcinidae	*Narcine brasiliensis*	9	F+M	21.0-042.0	0113-7370	0.016	0.0008 - 0.2808	2.875	2.0276 - 3.7155	0.357	0.95	I
Rhinobatidae	*Rhinobatos percellens*	62	F+M	45.5-075.7	0340-1729	0.0004	0.0001 - 0.0014	3.531	3.2233 - 3.8364	0.154	0.95	A (+)
Dasyatidae	*Dasyatis gutata*	36	F+M	36.0.007-99	1786-27000	0.048	0.0144 - 0.1582	2.906	2.6020 - 3.2107	0.15	0.96	I
	Dasyatis americana	21	F	46.2-091.0	2637-24295	0.173	0.0269 - 1.1051	2.56	2.1024 - 3.0171	0.219	0.94	A (-)
		24	M	35.0-074.0	0539-12389	0.002	0.0000 - 0.0331	3.716	2.9702 - 4.4616	0.36	0.91	A (+)
Gymnuridae	*Gymnura micrura*	6	F+M	14.6-026.4	0024-1620	0.003	0.0006 - 0.0142	3.313	2.7885 - 3.8364	0.189	0.99	I
Mobulidae	*Mobula hypostoma* (e)	3	F+M	32.6-071.4	0386-4800	0.004	0.0000 - 226.01	3.296	0.4192 - 6.1736	0.226	0.99	I
Myliobatidae	*Myliobatis freminvillei*	63	F+M	24.0-118.0	0227-12190	0.021	0.0062 - 0.0699	2.896	2.5981 - 3.1929	0.149	0.93	I

n=sample size; Lmin-max=minimal and maximal length; Wmin-max=minimal and maximal weight; F=females; Fi=immature females; M=males; Mi=immature males; Mm=mature males; e=embryos; *a*=intercept; CL=confidence limits; *b*=slope; SE=Standard error; R^2=coefficient of correlation; I=isometric; A(+)=Allometric positive; A(-)=Allometric negative; *= Disc width (DW) was the length used (all the rest Total Length).

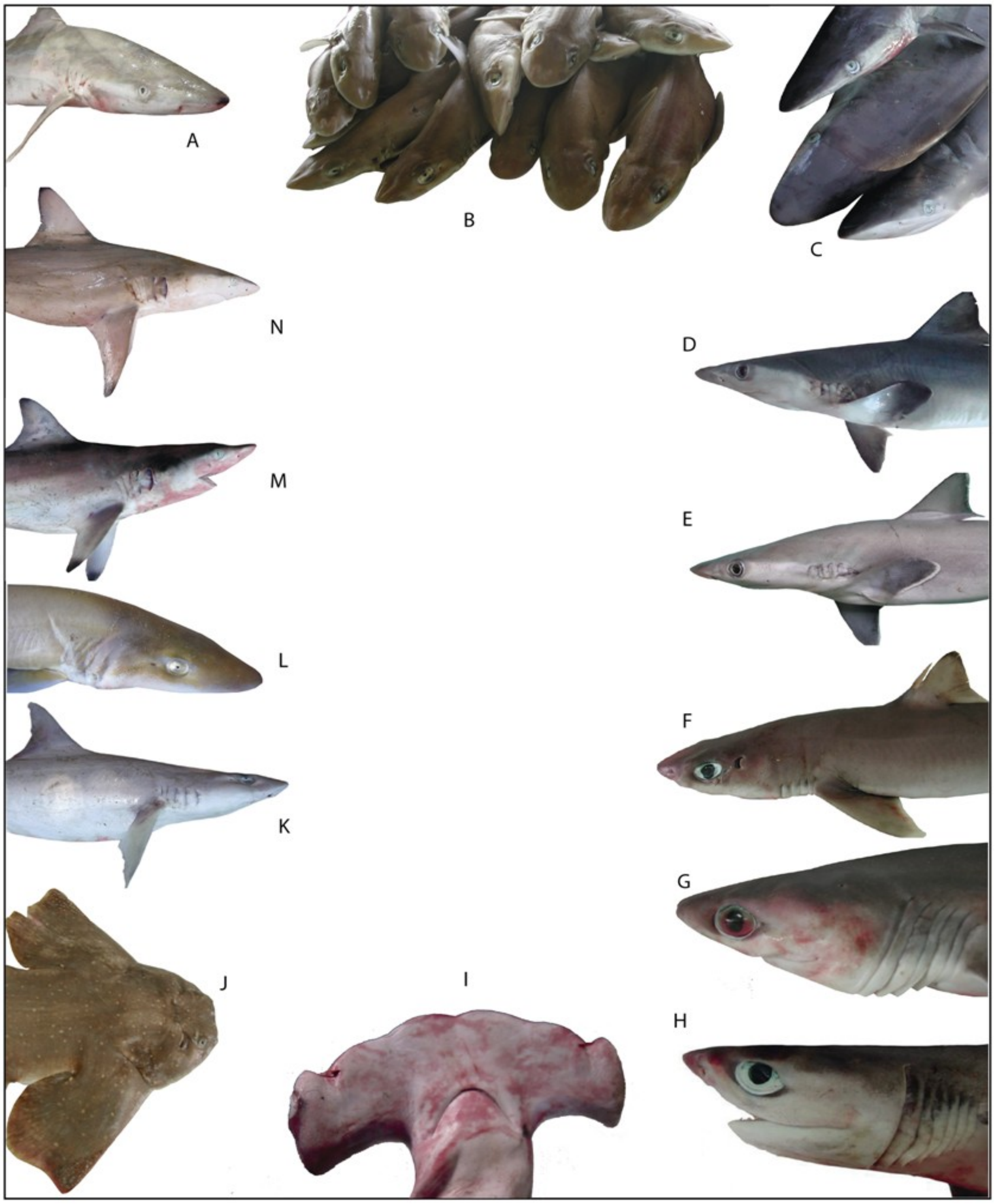

Figure 1. Sharks species analyzed: A) *Carcharhinus acronotus*; B) *Mustelus norrisi*; C) *Carcharhinus falciformis*; D) *Rhizoprionodon lalandei*; E) *R. porosus*; F) *Squalus cubensis*; G) *Hexanchus nakamurai*; H) *Heptranquias perlo*; I) *Sphyrna lewini*; J) *Squatina dumeril*; K) *Mustelus canis*; L) *M. higmani*; M) *Carcharhinus brevipinna* and N) *C. limbatus*. (Scales between species are not real).

and that the organisms analyzed in this work ranged between 34.6 and 106.4 cm of TL, and between 113 and 5499 g of weight, which includes organisms bigger and heavier than those analyzed by Gómez and Bashirulah (1984).

For *Mustelus higmani*, Etchevers (1975) did not find differences between males (n = 13) and females (n = 21) for LWR. In this work, statistic differences between sexes are reported (ANOVA, F (1,964) = 7.88, P<0.005), even between mature and immature males (ANOVA, F (1,417) = 21.43, P<0.001), perhaps due to a biggest sample size (n = 965). Additionally, a previous study on *C. limbatus* report a *b*-value of 3.028 for both sexes (Tavares, 2009), however in this work differences

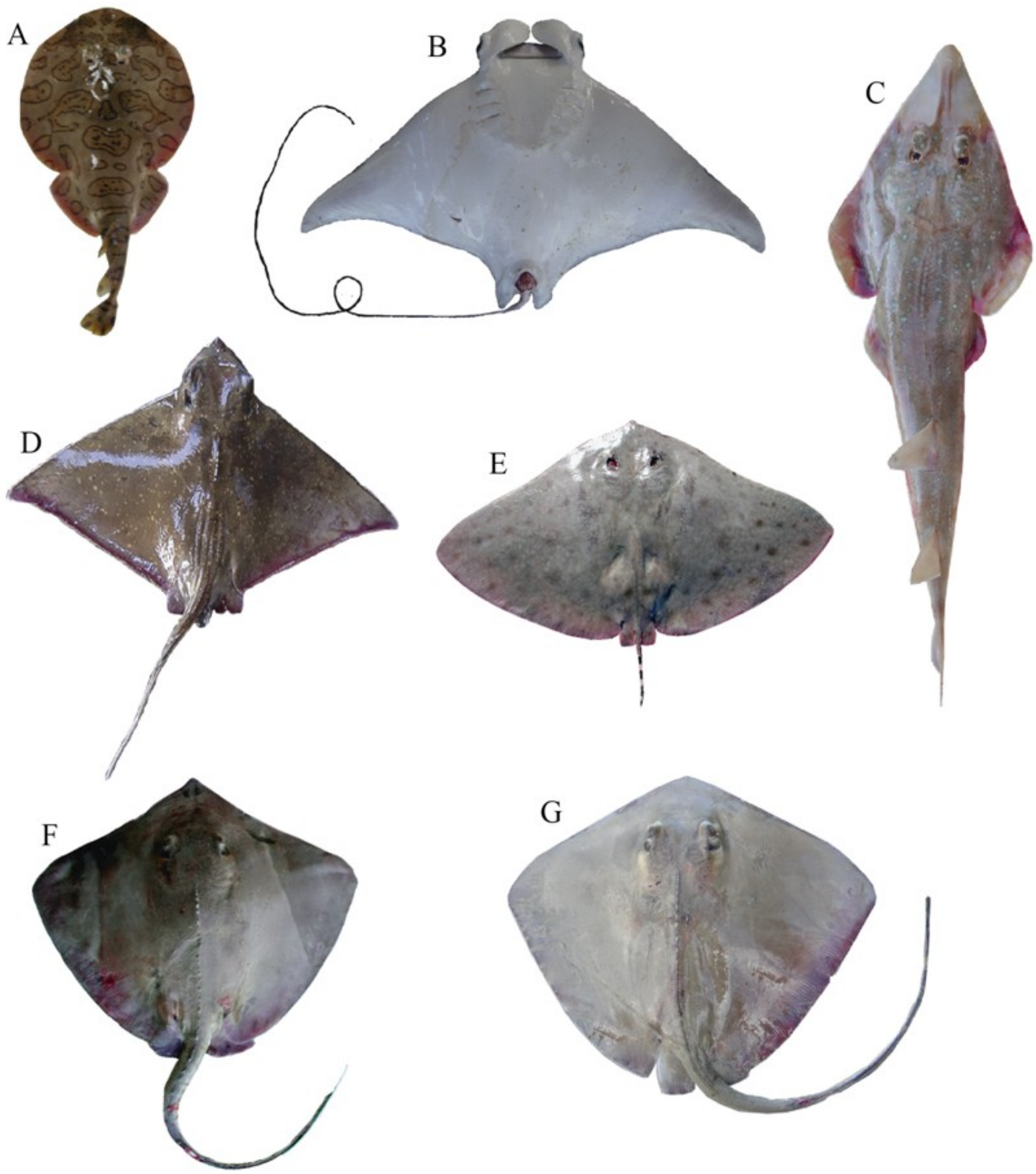

Figure 2. Batoids species analyzed: A) *Narcine brasiliensis*; B) *Mobula hypostoma*; C) *Rhinobatos percellens*; D) *Myliobatis freminvillei*; E) *Gymnura micrura*; F) *Dasyatis guttata* and G) *Dasyatis americana*. (Scales between species are not real).

between sexes were found (ANOVA, F (1,97) = 34.31, P<0.001) and as consequences two different LWR were made; also, different patterns of growth were reported for both sexes: females shows allometric positive growth (*b*=3.3), whereas males allometric negative growth (*b*=2.4). Different LWR for the same species can be attributed to sampling different populations or changes in the environmental conditions over time (Froese, 2006).

From around 32470 species of fishes contained in FishBase, LWR studies were only available for less than 12% (3587 species) (Froese *et al*., 2014), and if the same analysis is performed by country or region, the numbers become even smaller; which is the case in Caribbean waters, where information on the LWRs is limited to a few species.

CONCLUSION

To the best of our knowledge, no information currently exists in Venezuela on the LWR for 17 of the species studied (only *R. porosus*, *M. higmani*, *C. limbatus* and *C. falciformis* have been previously studied), and no LWR information is currently worldwide available for *Heptranchias perlo, Squalus cubensis, Squatina dumeril, Gymnura micrura, Myliobatis freminvillei* and *Mobula hypostoma* (Froese and Pauly 2011).

The coefficients of correlation of all the regressions in this study ranged between 0.7 and 0.99; all statistically significant (P<0.0001) and can be used to estimate weight from the length of individuals with similar length intervals.

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