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SHORT PAPER

Length-Weight Relationships of Five Elasmobranch Species from the Pacific Coast of Mexico

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Abstract

Length-weight relationships (LWR) were estimated for five elasmobranch species found in the Eastern Pacific: *Heterodontus francisci* (Girard, 1855), *Urobatis halleri* (Copper, 1863), *Urobatis maculatus* (Garman, 1913), *Diplobatis ommata* (Jordan and Gilbert, 1890), and *Rhinobatos productus* (Ayres, 1854). Species were selected because none had previously published data on LWR. The specimens were sampled along the Pacific west coast of Mexico, including the Gulf of California, between June 2009 and May 2013, using different fishing gear. The values of the exponent “b” of the LWR ranged from 2.52 to 3.06. This study provides the first reference on the LWR for these elasmobranch species.

Keywords: Length-weight, fisheries, sharks and rays, Eastern Pacific.

Introduction

The analyses that involve length-weight relationships (LWR) of fish species have increased because such data are useful, for example, for the conversion of growth-in-length equations to grow-in-weight. The parameters of LWR also have been applied to determining stock structure as well as for estimates of the fish condition and other fisheries applications (Mendes, Fonseca, & Campos, 2004). Nevertheless, available information on LWR of sharks and rays are not often reported or is very scarce (e.g. De Loyola- Fernández *et al.,* 2017; Texeira, Silva, Fabré, & Batista, 2017; Ismen, Yigin, Altinagac, & Ayaz, 2009; Yigin & Ismen, 2009; Yeldan & Avsar, 2007). In the west coast of Mexico, elasmobranchs are commonly fished by the artisanal fisheries as well as bycatch by shrimp and gillnet fisheries (Ehemann *et al.*, 2017). However, shark and ray populations have fallen drastically mainly due to its overexploitation. According to recent assessments, 36 species of elasmobranchs inhabiting Mexican waters are listed with some conservation status or control regime for their international trade (i.e. threatened, near threatened, critically endangered, and vulnerable) (Del Moral-Flores, Morrone, Alcocer-Durand, Espinosa-Pérez, & Ponce de León, 2015). An initial step to mitigate adverse impacts on natural resources and to support the development of proactive resolution responses is the generation and diffusion of primary biological data. To our knowledge, this study provides the first reference of LWR for five elasmobranch species that inhabit the Eastern Pacific, where they are endemic. Therefore, the primary objective of this study was to provide the specific information to compensate for this lack of knowledge.

Materials and Methods

Samples were collected along the northwest coast of Mexico (22°50'28.7"N - 110°12'12.8"W and 27°44' 40.6"N - 114°10' 7.1"W), including the Gulf of California (24°7'48"N - 109°53' 7.9"W and 26°58' 26.2"N - 111°56'54.7"W) within a multi-year collection program (June 2009- May 2013) for the study and evaluation of marine resources. The fish catches were made using a commercial bottom trawl net and long-line, and some were taken in local fishing grounds. Of all the species sampled, only those for which there was no published data for the LWR were selected for this study. In the laboratory, the fish were identified based on specific keys and all scientific names, authors, years and family assignments were checked against FishBase (Froese & Pauly, 2017). Each fish was measured to the nearest 0.1 mm (total length) and weighed with a digital balance, to the nearest 1 g (total weight). All specimen were firstly maintained in 10% buffered formalin solution and then preserved in 95% ethyl alcohol for subsequent deposit in the fish collection (CI) of the Centro Interdisciplinario de Ciencias Marinas in La Paz, Baja California Sur, México. The length and weight data were log-transformed and plotted for visual inspection of outliers; extreme outliers were omitted from the analyses (Froese, Tsikliras, & Stergiou, 2011). Parameters of the LWR were calculated for males and females combined, according to the formula: log W = log "a" + "b" log TL, where (W) is the total weight (g), (TL) is the total length (cm), "a" is the intercept, and "b" is the slope of the LWR (which indicates isometric growth in body proportions if b ~ 3) (Ricker, 1973; Froese, 2006). If a fish grows without changing its shape or its density, then the fish is said to exhibit isometric growth. In this case, the volume of the fish is proportional to any linear measure of its size. If a fish changes shape or density as it grows, then "b" is significantly different from 3, and the fish is said to exhibit allometric growth (Froese, 2006).The 95% confidence interval (CI) for parameters "a" and "b" was calculated according to Cohen, Cohen, West, & Aiken (2003).The coefficient of determination (R2) was used to evaluate the correlation between W and L. A test (Student's t-test; H0: b = 3; P<0.05) of whether the elasmobranchs studied exhibit isometric growth or not was applied, using the FishR Vignette by D. Ogle (http://derekogle.com/fishR/) implemented in the statistical software R. 3.3.1 (R Development Core Team, 2016). Ray individuals with broken or incomplete tails were not considered to avoid unreasonable parameter values. The LWR was analysed by software XLSTAT Pro© version 2010.

Results

In this LWR study, 244 elasmobranch specimens belonging to five species and four families were examined (other 23 were discarded as outliers). All samples sizes (N), minimum (Min) and maximum (Max) length and weight, parameters of LWR ("a" and "b"), 95% confidence intervals (CI) for these parameters, the coefficient of determination (R2) by species, and the growth type, are presented in Table 1. All regressions were highly significant (P<0.01), with the coefficient of determination equal or greater than 0.92 for all species studied. The estimated b values oscillated from 2.52 for the Shovelnose Guitarfish *R. productus* and 3.06 for the Horn Shark *H. francisci*. The species *D. ommata* and *R. productus* showed allometric growth, while the rest of species showed isometric growth.

Discussions

The five studied species had no previous LWR data in FishBase (Froese & Pauly, 2017) and therefore our results contribute to the knowledge of these elasmobranch species. Present values of "b" range between 2.52 and 3.06, falling within the expected range of 2.5–3.5, and all calculated values for "a", were within the range of 0.001 and 0.05, which validated these length-weight relationships estimates, as proposed by Froese (2006). However, our data are representative of a particular size or growth stage, and it is known that the LWR in fishes is affected by several factors (Froese, 2006) such as (1) environmental (seasonal variation, habitat type, geographic region), (2) biological (population, gonad maturity, sex, growth phase, diet, degree of stomach fullness, health and general fish condition), and (3) artifactual (preservation techniques, number of specimens examined, size range covered and type of length used). Thus, estimated parameters in the present work should be treated with caution or limited to similar fishery conditions and size ranges even though current parameters overlapped with the Bayesian confidence limits calculated interactively in FishBase (Froese, Thorson, & Reyes, 2014). It is recommended increasing information within the entire size range of each species studied. Finally, although there are no published records regarding LWRs of

Table 1. Length-weight relationships for 5 elasmobranch species caught on the coast of Mexico. LWR parameters are shown with 95% confidence interval (CI). All regressions were significant to (P<0.01)

	Parameters of the LWR						Length range TL (mm)			Weight range (g)				
Family/Species	N	*a*	*95% CI of a*	*b*	*95% CI of b*	R^2	Min	Max	Mean	Min	Max	Max	Growth Type /	*P* value
Heterodontidae														
Heterodontus francisci	22	0.006	0.003-0.012	3.06	2.83-3.29	0.98	135	476	306	18.2	777.9	282.8	Isometric	0.7389
Narcinidae														
Diplobatis ommata	50	0.021	0.009-0.033	2.82	2.62-3.00	0.98	43	218	122	1.1	125.5	5.01	Allometric	0.0038
Rhinobatidae														
Rhinobatos productus	34	0.080	0.027-0.113	2.52	2.34-2.71	0.97	92	351	167	12.3	534.7	108.7	Allometric	7.3e-05
Urotrygonidae														
Urobatis halleri	62	0.065	0.039-0.091	2.99	2.85-3.13	0.99	57	192	114	12.5	470.6	143.6	Isometric	0.8081
Urobatis maculatus	76	0.058	0.008-0.108	3.04	2.71-3.35	0.92	42	174	111	7.1	390	117.8	Isometric	0.5498

these species that would be comparable to the present results, they can provide a baseline for future studies concerning these elasmobranchs, some of which can be threatened by overfishing.

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