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

José De La Cruz-Aguero1,*, Francisco Javier García-Rodríguez1, Víctor Manuel Cota-Gómez1

1 Instituto Politécnico Nacional, Centro Interdisciplinario de Ciencias Marinas, Colección Ichtiológica. Avenida IPN s/n, Colonia Playa Palo de Santa Rita, La Paz, Baja California Sur 23096, México.

* Corresponding Author: Tel.: +52.612 1225344-81600; Fax: +52.612 1225344; E-mail: jcruz@ipn.mx

Abstract

Length-weight relationships (LWR) were estimated for five elasmobranch species found in the Eastern Pacific: Heterodontus francisci (Girard, 1855), Urobratis halleri (Copper, 1863), Urobratis maculatus (Garman, 1913), Diplobatis omnata (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, Fabrè, & Batista, 2017; Ismen, Yigin, Altinagac, & Ayaz, 2009; Yigin & Ismen, 2009; Yeldan & Avasar, 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 their 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°748″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 specimens 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, Mexico. 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 \( b \approx 3 \)) (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 were sampled in La Paz, Baja California Sur, Mexico. 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>
<thead>
<tr>
<th>Parameters of the LWR</th>
<th>Length range TL (mm)</th>
<th>Weight range (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family/Species</td>
<td>N</td>
<td>95% CI of a</td>
</tr>
<tr>
<td>Heterodontidae</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heterodontus francisci</td>
<td>22</td>
<td>0.006</td>
</tr>
<tr>
<td>Narcinidae</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diplobatis ommata</td>
<td>50</td>
<td>0.021</td>
</tr>
<tr>
<td>Rhinobatidae</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhinobatus productus</td>
<td>34</td>
<td>0.080</td>
</tr>
<tr>
<td>Urotrygonidae</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urotrygon maculatus</td>
<td>62</td>
<td>0.065</td>
</tr>
<tr>
<td>Urotrygon platostomus</td>
<td>76</td>
<td>0.058</td>
</tr>
</tbody>
</table>

**Tables**

**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)
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.

Acknowledgements

The authors would like to thank the support to the Ichthyology Collection (CI) at CICIMAR-IPN (http://coleccion.cicimar.ipn.mx) and SIP-IPN, CONABIO, and CONACyT. JDA and FJGR also appreciate the scholarly grants from SNI-CONACyT, COFAA-IPN, and EDI-IPN. Anonymous reviewers improved the manuscript with their comments and suggestions.

References


