Length-weight relationship of four batoid species from the Pacific coast of Ecuador

Relación longitud-peso de cuatro especies de batoideos de la costa del Pacífico de Ecuador

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Abstract - Length-weight relationships (LWR) were estimated for four species of batoids, Zapteryx xyster, Rostroraja equatorialis, Pseudobatos leucorhynchus and Gymnura crebripunctata, collected in Ecuadorian waters. Values of the allometric growth parameter (b) oscillated from 2.41 to 3.15. Pseudobatos leucorhynchus and G. crebripunctata exhibited isometric type growth, while Z. xyster and R. equatorialis showed negative and positive allometric growth, respectively. New records of minimum sizes were obtained for free-swimming R. equatorialis (7.8 cm TL) and G. crebripunctata (20.0 cm DW). Data obtained constitute a baseline for future management and conservation studies.

Key words: Length-weight, batoids, Ecuadorian waters

INTRODUCTION

Length-weight relationship (LWR) is a useful approach that provides basic data on population dynamics of the species, which facilitates their management and conservation through the formulation of fisheries management measures (Froese 2006, Koushlesh et al. 2017, Correia et al. 2018, Wei et al. 2019). LWR analysis is used to assess weight of an organism from a determined length (Froese 2006); understanding changes in fish weight as a function of size is essential information to deduce age structure, calculate growth rates or quantify some other aspect of fish population dynamics (Jellyman et al. 2013, Wang et al. 2013, Liu et al. 2018). Recently, a number of LWR of batoids have been reported (Romero-Caicedo et al. 2015, Rastgoo et al. 2016, Ehemann et al. 2017, Gladston et al. 2018, González-González & Ehemann 2019); however, life history of many batoids are still unknown or have been little studied (Dulvy et al. 2014).

In Ecuador, batoids are caught as part of bycatch of fishing fleets that operate with shrimp trawls and bottom gill nets. Most of these organisms are discarded and some are destined for local consumption or converted into fishmeal (Martínez-Ortiz & García-Domínguez 2013). Information of this biological group is scarce. Thus, the current work aim to determine LWR parameters of four batoid species caught in Ecuadorian waters, being one of the first reports about life cycle of Gymnura crebripunctata (Peters, 1869) and Rostroraja equatorialis (Jordan & Bollman, 1890), and an increase in the biological knowledge of Pseudobatos leucorhynchus (Günther, 1867) and Zapteryx xyster Jordan & Evermann, 1896. This information is important for subsequent population assessment, allowing the proposal of management measures for these resources.

MATERIALS AND METHODS

Specimens of the four batoid species were collected from shrimp trawlers as bycatch along the Ecuadorian coast (1°36′N and 79°12′W to 03°01′S and 80°44′W), between 20 and 80 m depth, from October 2016 through August 2017. A total of 12 fishing trips were monitored, information on four batoid species was registered randomly of 49 shrimp trawl spears. Trawl nets had a dimension between 30 and 35 m long and a mesh size of 3.8-5.0 cm. Trawl lasted between 3 and 4 h, with speeds of 1.8 to 2 kt.
All specimens were identified using the identification guide of Last et al. (2016). Sex was identified by the presence (males) or absence (females) of claspers. Size was recorded by means of a measuring tape with a precision of 0.1 cm; for each specimen, the total length (TL, ± 0.1 cm) was recorded from tip of rostral to distal point of caudal; in the case of Gymnura crebripunctata, the disc width (DW, ± 0.1 cm) was registered measured as the straight-line distance between the two outermost points of pectoral fins (Romero-Caicedo et al. 2015). Total weight (TW) was measured to the nearest gram (g) using a digital balance (W, ± 0.1 g).

Total length was used for the length-weight relationship (LWR), except for G. crebripunctata where it was replaced by DW. LWR was described using a power model $W = a \cdot TL^b$ or $W = a \cdot DW^b$, where $a$ and $b$ are parameters of the model estimated as the linear regression between log (W) and log (TL) or log (WD), meaning $\log W = \log a + b \cdot \log TL$ or $\log W = \log a + b \cdot \log DW$ (Froese 2006). 95% confidence limits were calculated for parameters $a$ and $b$, as well as coefficient of determination ($r^2$) to quantify variation of model explained by length-weight relationship. LWR was evaluated for males and females of each species and sexual differences were tested by length-weight relationship. LWR was evaluated for males and females of each species and sexual differences were tested by ANCOVA, using size as a covariant (Zar 1999), with a significance level of 0.05. Type of growth for all species was determined by the slope $b$, when $b > 3$, the species presents an isometric growth, whereas allometric growth is negative or positive when $b < 3$ or $>3$, respectively (Froese 2006), and it was evaluated using a Student’s t test for slopes ($H_0: b = 3$). All analyse were done using R (R Core Team 2013) and the package FSA (Ogle et al. 2018).

**RESULTS AND DISCUSSION**

A total of 1,424 organisms of all species were analyzed. Results of the model for species and sex, sample size, minimum and maximum value of length and weight, estimates of parameters $a$ and $b$ with their confidence intervals (CI; 95%), coefficient of determination ($r^2$), Student’s t test for slopes with their level of significance, and growth type are shown in Table 1.

Minimum total lengths herein reported were the smallest values for free-living organisms of R. equatorialis and G. crebripunctata, with 7.8 cm TL and 20.0 cm DW, respectively. Other studies carried out in the Eastern Pacific coast record minimum sizes of 25.0 cm TL for R. equatorialis (Martínez-Ortiz & García-Domínguez 2013) and 29.0 cm DW for G. crebripunctata (Smith et al. 2009). The current study provides new minimum lengths for these species along the Ecuadorian coast; these new registers can be a result of fishing effort, combining two factors: catches in areas near the coast (20-80 m of depth) and a small mesh size (3.8-5.0 cm), as smaller organisms can be entangled in fishing gears. Thus, elasmobranchs, during the first stages of their life cycle, prefer shallow waters where they can easily find preys and havens (Simplendorfer & Milward 1993, Salomón-Aguilar et al. 2009).

A minimum size of 14.3 cm TL was recorded for Z. xyster. The smallest size recorded worldwide for this species was found in Costa Rican waters with 14.0 cm TL (Espinoza et al. 2015). Present results represent the smallest size in Ecuadorian waters, where there were records of a minimum size of 38 cm TL (Martínez-Ortiz & García-Domínguez 2013). Minimum and maximum total lengths of 21.0 and 118.0 cm, respectively, have been reported for P. leucorhynchus in Ecuadorian waters by Romero-Caicedo et al. (2015), which differs from reported in the current study, with a maximum total length of 76.1 cm, also reported in Colombian waters (76.0 cm LT) (Payán et al. 2011).

Length-weight relationships for the species showed $r^2$ values ranging from 0.92 to 0.98; therefore, these estimations can be considered near to adequate. Analysis by sex also showed high values of $r^2$ (0.97 to 0.99), except for males of G. crebripunctata ($r^2 = 0.66$), which may be due to low sample number or the range of limited sizes for males. According to Froese et al. (2011), when determination coefficient ($r^2$) is minor than 0.95 it may indicate outliers, due to the inclusion of extreme individuals such as juveniles (minor size) or adults (major size), abrupt change of shape during development, sex-differences, seasonal differences, among others.

First records of growth type are provided for R. equatorialis and G. crebripunctata (Table 1). Allometric growth parameter $b$ for R. equatorialis was 3.11 (positive allometric growth) and G. crebripunctata showed isometric growth (2.94). For Zapteryx xyster values showed negative allometric growth ($b = 2.92$), this type of growth is similar as the one reported in the Southwest Atlantic Ocean for Z. brevirostris, a congener species (Pasquino et al. 2016), but differs from the value reported in a previous work in the Colombian Pacific of $b = 2.85$, interpreted by the authors as isometric growth (Mejía-Falla et al. 2006). Isometric growth herein reported for P. leucorhynchus differs from other studies in Colombian and Ecuadorian Pacific, where allometric growth rates were reported by Payán et al. (2011) and Romero-Caicedo et al. (2015). Male and female presented the same type of growth, except for G. crebripunctata, where an isometric growth was observed for females ($b = 3.12$), and negative allometric growth for males ($b = 2.41$) (Table 1), however, as proposed by Froese et al. (2011), a re-evaluation of these type of cases is suggested.
According to ANCOVA analysis, significant differences were not found in LWR between sex for three species (P. leucorhynchus: $F = 0.055, P > 0.05$; Z. xyster: $F = 2.498, P > 0.05$; R. equatorialis: $F = 0.088, P > 0.05$), while G. crebripunctata did present differences ($F = 9.706 P < 0.05$), in which males had a negative allometric growth. Our results with other studies show that the values of $b$ can be affected by several factors, such as differences in the number of examined organisms, area, season, or the use of different lengths (Froese et al. 2011, Pan et al. 2014, Ehemann et al. 2017).

This study represents the first contribution to knowledge of biological aspects for G. crebripunctata and R. equatorialis; as well as an increase in the life history information of P. leucorhynchus and Z. xyster in the Ecuadorian waters. The data obtained constitutes a baseline for future models used for fisheries resources management and conservation, however, it is suggested that the results of these relationships be used only with the presented length ranges.

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**LITERATURE CITED**

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