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Research Article

The Length–Weight Relationship in Food Fish Species From the Upper Putumayo River Basin, Colombia

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The length–weight relationship (LWR) in fish is an important tool because it allows understanding aspects such as growth assessment, body condition, and biomass estimation. The aim of this study was to determine the LWR of food fish species from the Amazonian plain of the Putumayo River caught by artisanal fisheries to be sold in the town of Puerto Leguízamo between 2018 and 2023. More than 19,000 individuals of 31 species were registered. Each fish was taxonomically identified at the species level, recording its standard length (cm) and weight (g). Searches in FishBase revealed that six species lack referenced data, twenty five are not reported for the Putumayo Basin, and five are in the vulnerable category, according to the International Union for Conservation of Nature (IUCN). The relationship data calculated in this study are the first publications for these species in this region of the Amazon Basin. Knowledge of these biometric data and their relationships is relevant for managing and conserving fish and fisheries.

Keywords: Amazon basin; fisheries biology; Putumayo-Ica

1. Introduction

The Putumayo watershed in the Colombian Amazon is home to 470 fish species [1]; 17 percent of these, i.e., 80 species, are used for commercial fishing and self-consumption (unpublished data). According to the IUCN Red List, Colombia has 22 species, 16 of which are classified as vulnerable (VU) [2]. Overfishing, the degradation of aquatic environments, population growth, and limited action by regulatory authorities jeopardize the population status of the ichthyofauna [3].

Length–weight relationships (LWRs) are an important tool in fisheries science because they allow biomass to be estimated from landing data when only length measurements are available [4]. They are even more valuable in isolated areas of the Amazon where community monitoring programs are being conducted, where weighing equipment is not readily available, or in crowded collection centers where fish weighing is impractical. In these circumstances, length data are more accessible and provide a reliable basis for converting them into biomass figures [5].

In the Putumayo River Basin, the lack of knowledge about the morphometric relationships of food fish limits regional knowledge of stocks and hinders fisheries management. Accordingly, the aim of this study is to establish the LWR for 31 high-value fish species for local people. The results in this publication provide valuable biometric information on these fish species and can aid in sustainable fisheries management by coastal communities and fisheries authorities in the triborder area of Colombia, Peru, and Ecuador, as well as becoming input for future research.

2. Materials and Methods

The specimens were collected between January 2018 and December 2023 in fishing landings in Puerto Leguízamo

FIGURE 1: Location of the study area in the upper Putumayo River, Puerto Leguízamo, Colombia.

(0.20°S, 74.78°W) located in the Putumayo River Basin on the triple border of Colombia, Peru, and Ecuador (Figure 1). Artisanal fishers employed two methods for the capture. The first method utilized monofilament surface gillnets. The length of these nets ranges from 40 to 100 m long with 30–50 meshes in height. Mesh sizes (from knot to knot) can be 2.5, 3.0, and 3.5 inches. The second fishing method uses a nylon line with 30–50 hooks, size #6, submerged perpendicularly to the main river channel. Hooks are baited with fish parts.

The specimens collected were taxonomically identified and validated by comparison to individuals from the Amazonian ichthyological collection of Instituto Amazónico de Investigaciones Científicas SINCHI (https://sinchi.org.co/ciacol). The weight–length relationship of species was estimated using the following equation.

$$W_t = a * SL^b, \quad (1)$$

where W_t is the total weight (g), S_L is the standard length (cm), a is the intercept, and b is the slope of the linear (log-transformed) version [4] estimated using the following equation.

$$\log(W_t) = \log(a) + b * \log(S_L). \quad (2)$$

The presence of outliers for each species was identified graphically using log (S_L) versus log (W_t) [6], removing obvious outliers. The 95% confidence intervals (CIs) and the coefficient of determination (r^2) of the regression parameters a and b were calculated.

3. Results

A total of 19,630 individuals belonging to 31 species and 12 families were measured and weighed. Sample sizes ranged from 32 to 4850 data points. The three species with the highest number of records were *Calophysus macropterus* with 4,850, followed by *Brachyplatystoma platynemum* with 3314 and *Brachyplatystoma juruense* with 2346, highly appreciated commercially in this region. The results of the LWR are presented in Table 1. The b parameter for all species ranged from 2.24 to 3.45. The lowest b value corresponded to *Potamorhina altamazonica* (2.24), while the highest was recorded for *Exallodontus aguanai* (3.45). In the regression analysis, the r^2 value was used to evaluate the goodness of fit of the model. The species with the best fit ($r^2 = 0.989$) was *Sorubimichthys planiceps*, while the poorest fit was *Hypophthalmus oremaculatus* ($r^2 = 0.611$). Six of the 31 species analyzed had no LWR record available in FishBase [7], and 25 had LWR records but no representation for the Putumayo River Basin.

4. Discussion

The parameters of the calculated relationships can vary significantly depending on sex and hydrological season, as well as other factors such as growth phase, gonadal development, stomach contents, and health status [8–11]. Since individuals were collected over an extended period, these data do not represent a specific season or time, and for

TABLE 1: Length–weight relationship (LWR) for 31 species from the upper basin of the Putumayo River.

Family species	N	S_L (cm) Min.	Max	W_t (g) Min.	Max.	a	a (95% CI)	b	b (95% CI)	r^2	Growth pattern
Osteoglossidae											
Osteoglossum bicirrhosum (Cuvier, 1829)	223	22.0	96.0	98.0	5150.0	0.0059	0.0048–0.0073	3.0613	3.0101–3.1125	0.984	Positive
Pristigasteridae											
Pellona castelnaeana (Valenciennes, 1847)	97	22.8	70.7	162.9	6500.7	0.0098	0.0072–0.0132	3.1311	3.0495–3.2127	0.984	Positive
Pellona flavipinnis (Valenciennes, 1837)	63	17.8	39.2	81.0	685.0	0.0129	0.0068–0.0247	3.0347	2.8357–3.2337	0.938	Positive
Anostomidae											
Schizodon fasciatus (Spix and Agassiz, 1829)	109	17.1	37.8	126.0	1220.4	0.0104	0.0061–0.0180	3.1529	2.9856–3.3203	0.929	Positive
Bryconidae											
Brycon amazonicus (Spix and Agassiz, 1829)	274	15.9	43.0	138.2	2200.0	0.0419	0.0333–0.0528	2.8153	2.7473–2.8834	0.961	Negative
Brycon hilarii (Valenciennes, 1850)	73	10.0	39	66.2	641.5	0.0529	0.0278–0.1007	2.7247	2.5216–2.9278	0.910	Negative
Brycon melanopterus (Cope, 1872)	824	19.0	27.7	162.4	485.8	0.0218	0.0146–0.0327	3.0120	2.8825–3.1416	0.717	Positive
Curimatidae											
Potamorhina altamazonica (Cope, 1878)	772	13.3	24.0	54.6	234.3	0.1864	0.1483–0.2343	2.2447	2.1664–2.3230	0.804	Negative
Potamorhina latior (Spix and Agassiz, 1829)	176	16.1	23.6	66.9	185.2	0.0267	0.0137–0.0518	2.8515	2.6262–3.0768	0.782	Negative
Erythrinidae											
Hoplias malabaricus (Bloch, 1794)	102	11.3	39	41.0	1342.5	0.0241	0.0178–0.0326	2.9561	2.8632–3.0490	0.976	Negative
Prochilodontidae											
Prochilodus nigricans (Spix and Agassiz, 1829)	199	8.2	33.9	98.1	703.1	0.0461	0.0355–0.0598	2.7832	2.6995–2.8668	0.956	Negative
Serrasalmidae											
Mylossoma albiscopum (Cope, 1872)	530	8.8	24	32.7	661.3	0.0565	0.0491–0.0649	2.8905	2.8396–2.9414	0.959	Negative
Pygocentrus nattereri (Kner, 1858)	110	12.3	25.3	66.0	697.5	0.0368	0.0265–0.0512	3.0229	2.9074–3.1383	0.961	Positive
Auchenipteridae											
Ageneiosus inermis (Linnaeus, 1766)	214	17.8	48.8	100.0	1901.0	0.0148	0.0106–0.0205	3.0123	2.9196–3.1050	0.951	Positive
Pimelodidae											
Brachyplatystoma juruense (Boulenger, 1898)	2346	41.8	67.9	992.0	5345.0	0.0065	0.0057–0.0074	3.2143	3.1820–3.2489	0.938	Positive
Brachyplatystoma platynemum (Boulenger, 1898)	3314	38.2	94.6	737.0	10,680.0	0.0067	0.0061–0.0074	3.1153	3.0923–3.1384	0.955	Positive
Brachyplatystoma vaillantii (Valenciennes, 1840)	50	34.7	63.9	675.0	3016.0	0.0056	0.0021–0.0152	3.2553	2.9950–3.5156	0.929	Positive

Table 1: Continued.

Family species	N	S_L (cm) Min.	S_L (cm) Max	W_t (g) Min.	W_t (g) Max.	a	a (95% CI)	b	b (95% CI)	r^2	Growth pattern
Brachyplatystoma tigrinum (Bristki, 1981)*	**32**	**43.2**	**64.8**	**870.4**	**3000.0**	**0.0198**	**0.0070–0.0561**	**2.8409**	**2.5792–3.1027**	**0.942**	**Negative**
Calophysus macropterus (Lichtenstein, 1819)	4850	22.5	52.7	160.0	1453.0	0.0119	0.0112–0.0126	3.0289	3.0118–3.0461	0.961	Positive
Exallodontus aguanai (Lundberg, Mago-Leccia, and Nass, 1991)*	**33**	**15.4**	**25.5**	**81.0**	**244.5**	**0.0032**	**0.0009–0.0115**	**3.4500**	**3.0311–3.8688**	**0.901**	**Positive**
Hemisorubim platyrhynchos (Valenciennes, 1840)	62	22.3	49.5	128.0	1410.0	0.0171	0.0082–0.0357	2.9105	2.6961–3.1249	0.925	Negative
Hypophthalmus celiae (Littmann, Lundberg, and Rocha, 2021)	878	23.8	48.5	109.0	1070.0	0.0065	0.0047–0.0091	2.9995	2.9085–3.0906	0.827	Negative
Hypophthalmus oremaculatus (Nani and Fuster, 1947)	350	25.9	37	135.5	370.5	0.0255	0.0118–0.0550	2.6599	2.4361–2.8836	0.611	Negative
Leiarius marmoratus (Gill, 1870)	448	30.4	73.8	453.0	5905.1	0.0045	0.0033–0.0062	3.3272	3.2462–3.4082	0.936	Positive
Megalonema platycephalum (Eigenmann, 1912)	56	17.2	32.2	65.9	498.0	0.0055	0.0033–0.0094	3.2989	3.1298–3.4680	0.966	Positive
Pinirampus pirinampu (Spix and Agassiz, 1829)	1412	25.4	65.0	196.0	3365.0	0.0105	0.0092–0.0120	3.0431	3.0078–3.0783	0.953	Positive
Platynematichthys notatus (Jardine, 1841)	239	34	76.5	581.0	7100.0	0.0069	0.0053–0.0089	3.1834	3.1138–3.2531	0.972	Positive
Pseudoplatystoma punctifer (Castelnau, 1855)	952	27	105.3	229.0	6994.0	0.0135	0.0113–0.0162	2.9462	2.9012–2.9912	0.946	Negative
Sorubimichthys planiceps (Spix and Agassiz, 1829)	61	44.5	131.6	507.0	6545.0	0.0053	0.0037–0.0076	3.0357	2.9511–3.1203	0.989	Positive
Cichlidae											
Cichla monoculus (Spix and Agassiz, 1831)	449	16.6	48.6	98.0	1777.0	0.0293	0.0235–0.0367	2.8961	2.8293–2.9629	0.942	Negative
Sciaenidae											
Plagioscion squamosissimus (Heckel, 1840)	332	16.0	62.5	92.6	3058.2	0.0213	0.0162–0.0280	2.9493	2.8690–3.0295	0.941	Negative

Note: N: sample size; *a*: intercept; *b*: slope; growth pattern: positive or negative allometric. Species with a small sample size in bold.
Abbreviations: CI, confidence interval; Max, maximum; Min, minimum; SL, standard length (cm); Wt, total weight (g).
*The estimate is indicated as "tentative."

comparative purposes, they should be considered only as annual means. This study provides biometric information for 31 food fish species from the Putumayo Basin, including migratory goliath catfishes (*Brachyplatystoma*, Pimelodidae), the most threatened genus in the Amazon Basin [12]. The first LWR is provided for *Brachyplatystoma juruense*, *Brachyplatystoma platynemum*, *Brachyplatystoma tigrinum*, *Exallodontus aguanai*, *Megalonema platycephalum*, and *Pseudoplatystoma punctifer*, which do not have data in FishBase [7]. The estimation of the LWR for *B. tigrinum* and *E. aguanai* is tentative due to the reduced sample size. Nevertheless, the results will be valuable for fisheries studies and can be considered a reference for the Colombian Amazon. The expected b value range (2.5–5.5) was met in 96.8% (30 species), according to Froese [4], who indicated that values should typically be between 2.5 and 3.5. When $b = 3$, growth is isometric, i.e., specimens maintain their shape as they grow (weight proportional to volume); $b < 3$ indicates negative allometric growth, where the fish becomes longer or thinner as it grows, and when $b > 3$, allometric growth is positive, i.e., the individual is more robust or "fatter" in relation to its length. As an exceptional case, a strong negative allometric growth (2.24) was found in *Potamorhina altamazonica* despite having a large sample size, which may be associated with the lack of individuals at different growth stages or the seasonal and interannual hydrological effects that occur in the Amazon [4, 13]. The species recorded r^2 values ranging from 0.611 to 0.989. These values may correspond to changes in the natural body condition associated with reproductive seasons, migrations, or gear selectivity [14] or an inadequate representation of the size classes.

5. Conclusion

The results recorded in this study for 31 food fish species from the Putumayo River Basin are fundamental because they provide biometric data for poorly documented ecologically and economically important fish species. This information provides a practical tool for fisheries biology, allowing for more accurate biomass estimates when only length measurements are available, as is often the case in the Amazon, where weighing individuals is rare. The LWR is fundamental for the conservation and management of fishery resources in artisanal fisheries in the Amazon, as it serves as a basis for fishery assessment models, allows monitoring of fishing pressure through changes in its parameters over time, identifies species growth patterns, and acts as an indicator of fish body condition. LWR is reported for six species lacking data referenced in FishBase and 25 unreferenced species for the Putumayo River Basin. The data provided in this study are crucial for managing multispecies fisheries in the Putumayo River Basin, given the high diversity of its fish fauna.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest.

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