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Short Communication

LENGTH-WEIGHT RELATIONSHIP OF THE SIX MOST ABUNDANT FISH SPECIES IN PRAWN FISHERY SEMI-FIXED TRAP BYCATCHES IN THE LOWER AMAZON REGION (PARÁ, BRAZIL)

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ABSTRACT

In this study, the length-weight relationships (LWR) were estimated for six fish species captured during prawn fishing in the Lower Amazon region (Pará, Brazil). Prawn fishing boosts the socioeconomic development of riverine communities and is a relevant activity as a source of income and subsistence in this region. In addition, we registered new LWRs for the species *Ossancora punctata* and *Hypoptopoma elongatum.* The samplings were performed in prawn catches monthly from February 2018 to January 2019, using a "matapi", which consists of a semi-fixed trap that has a galvanized iron structure (2.5 m height by 2.0 m in length) and nylon mesh (1.40 x 1.60 mm mesh), and has two tapered openings to facilitate the entry and trapping of the prawn. The results show that 75% of the fish caught as prawn bycatches had not yet reached sexual maturity. Thus, it is clear that fisheries need to develop fishing gear that allow small fish to escape from the traps during the prawn fishery.

Keywords: bycatch; inland fisheries; Amazon basin.

RELAÇÃO PESO-COMPRIMENTO DAS SEIS ESPÉCIES DE PEIXES MAIS ABUNDANTES NA PESCA DE CAMARÃO EM ARMADILHAS SEMIFIXAS NA REGIÃO DO BAIXO AMAZONAS (PARÁ)

RESUMO

Neste estudo, as relações de peso-comprimento (RPC) foram estimadas para seis espécies de peixes capturadas durante a pesca do camarão de água doce na região da Baixa Amazônia (Pará, Brasil). A pesca do camarão promove o desenvolvimento socioeconômico das comunidades ribeirinhas, sendo uma atividade de fonte de renda e subsistência nesta região. Além disso, registramos novas RPCs para as espécies *Ossancora punctata* e *Hypoptopoma elongatum*. As amostragens foram realizadas mensalmente em capturas de camarão, entre fevereiro de 2018 e janeiro de 2019, com o uso de "matapi", que consiste em uma armadilha semifixa, com estrutura de ferro galvanizado (com altura de 2,5 m por 2,0 m de comprimento) e tela de náilon (malha de 1,40 mm x 1,60 mm), com duas aberturas afuniladas para facilitar a entrada e aprisionamento do camarão. Os resultados mostraram que 75% dos peixes capturados como fauna acompanhante de camarão ainda não tinha atingido a maturidade sexual. Assim, é evidente que as pescarias precisam desenvolver equipamentos de pesca que permitam que os peixes menores escapem da captura durante a pesca do camarão.

Palavras-chave: fauna acompanhante; pesca interior; bacia Amazônica.

INTRODUCTION

The length-weight relationship (LWR) of fish species is an important tool for biology and ecology and can also be used in the evaluation of fishery management, since it is a parameter that indicates the condition factor (i.e., fat accumulation and gonad development) of the fish population. These data are helpful in biomass calculations and generate indirect information on maturity, reproduction, and nutrition (Froese et al., 2011, 2014), which are frequently used for economically important fish. The length and weight parameters also permit growth comparisons between species from different regions, as well as the

monitoring of the health of stocks over time (Vaz-dos-Santos and Rossi-Wongtschowski, 2013; Silva et al., 2020).

This study aimed to determine the LWR of six species of the most abundant teleost fish species (*Colomesus asellus*, *Centromochlus heckelii*, *Pimelodus blochii*, *Pimelodella cristata, Hypoptopoma elongatum* and *Ossancora punctat*a), which are often bycatches of the Amazonian freshwater prawn (*Macrobrachium amazonicum*) fisheries that are carried out in the Lower Amazon (Pará, Brazil). These species of fish are also neglected as accompanying fauna of prawn fishing, where they are most often discarded or underused.

MATERIAL AND METHODS

The fish specimens were obtained monthly from prawn catches during the period from February 2018 to January 2019, using three designated semi-fixed traps (known locally as "matapi") that were destined for commercial fishing of the Amazonian freshwater prawn (see details in Imbiriba et al., 2020). In this region, the matapi consists of a galvanized iron structure and nylon mesh (mesh 1.40 x 1.60 mm). Although there is no standard size, the matapi generally does not exceed a size of 2.5 m high by 2.0 m long, and it has two tapered openings to facilitate the entry and trapping of prawn. The total capacity of the equipment was not measured. The traps remained in the water for approximately 12 hours during the night. The traps were located on the right bank of the Amazon River in front of the urban area of the city of Santarém, Pará state (2°26'09.8"S - 54°40'54.1"W; 2°27'09.0"S - 54°38'58.3"W; 2°26'33.0"S - 54°40'33.4"W). The fishing of the prawn is carried out by small vessels of an artisanal fleet (Coelho et al., 2020), and the researchers followed the emptying of the traps together with the fishers, at which time the fish trapped in the matapis were collected for this study.

The region has low thermal amplitudes and accumulated annual precipitation greater than 2,000 mm; the rainy season occurs between December and June and the dry is between July and November (Silva et al., 2016). The average oscillation of the water level is marked by the flood pulse, which is divided into four phases of the hydrological cycle: rising water (December to March), flood (April to June), receding water (July to September) and low water (October and November) (Bentes et al., 2018).

After removal from the trap, each fish was immediately euthanized by spinal cord sectioning (CFMV, 2012), stored in a thermal box with ice and transported to the laboratory, where it was then thawed and identified using taxonomy guides and by specialists (Ferreira et al., 1998; Ohara et al., 2017). Each specimen had its total weight and total length accurately measured to within 0.1 g/0.1 cm. The scientific names and year of description are in accordance with Fricke et al. (2020).

The LWRs of the species were determined by regular linear regression and Bayesian analysis (Froese, 2006; Froese et al., 2014; Lima and Sousa, 2020). The relationship of outliers was identified, and these were removed before analysis. The length-weight function is calculated by the equation $W = aL^b$, where W is the weight (g), L is the total length (cm), a is a constant and b is the allometric coefficient. Therefore, some differences occur around the allometric coefficient that are related to the biological aspects of each species (Silva et al., 2008). Thus, when $b = 3$, the species has an isometric growth; if $b < 3$, the growth is negatively allometric, and when $b > 3$, the growth is positively allometric (Mereles et al., 2017). In the case of our study, the parameters a and b were determined by linear regression: $logW = loga + b$. The 95% confidence interval (CI) was determined for parameters a and b. The r-squared (r^2) Pearson correlation coefficient was estimated. The allometric condition factor K_{rel} was calculated according to the equation $K_{rel} = \frac{W}{aL^b}$ (Le Cren, 1951). The Bayesian analysis was employed with a code-to-use found in Froese and Pauly (2019). The prior probabilities were obtained from data provided for the Xingu River, Madeira River, or from estimates using Bayesian analysis of data from FishBase (Froese and Pauly, 2019) in cases of non-occurrence, which were combined with the new data from this study (likelihood function). The package R2jags (Su and Yajima, 2015) and the JAGS sampler software (Plummer, 2017) were used for the Bayesian analyses. All the analyses were done using the R Statistical Environment software (R Core Team, 2019).

RESULTS

The LWRs of the six species of teleost fish were analyzed since these species represented the most abundant organisms in the bycatches of the Amazonian freshwater prawn fisheries, as reported by Imbiriba et al. (2020). The most diverse order was that of the Siluriformes, for which five species occurred in the sampling. Table 1 summarizes the results of the number of collected species, minimum values and maximum length recorded, the LWRs, K_{rel} and the coefficients of determination for each fish species.

The species showed significant differences in regressions of the length-weight relationship ($p < 0.001$). The constant (a) for the LWRs ranged from 0.0089 to 0.0221. The allometric coefficient (b) ranged from 2.8192 and 3.2384 in conventional analysis, while, when using Bayesian analysis, it was between 2.7300 and 3.0700. All condition factor values were above 1,000.

DISCUSSION

The data recorded from the analyzed fish species complement the information on the LWRs and indicate that small fish are caught only as bycatches in the prawn fisheries. The values of a and b corroborate the scale of the data, as proposed by Froese (2006). The species *O. punctata* and *H. elongatum* had no previous LWRs recorded in the literature, either nationally or internationally, however the latter presented a larger size (10.6 cm) than what is registered on FishBase (Froese and Pauly, 2019). Thus, this study is the first report of the a and b parameters for these species in the Lower Amazon region (Pará, Brazil). As such, among the four fish species already registered on the FishBase database (but with little data available in the scientific literature), the b parameters of the LWRs exhibited negative allometric values with $b < 3$ for all fish species. These were lower than those previously recorded, except

Table 1. Length-weight relationship determined by linear regression and Bayesian analysis of the six teleost fish species captured incidentally during the Amazonian freshwater prawn fishing in the Lower Amazon, Pará state, Brazil.

Order/Family/Species	N	TL (cm)		TW (g)		LW Regression parameters				Bayesian analyses	
		Min	Max	Min	Max	*a* (95% CI)	*b* (95% CI)	r^2 (95% CI)	K_{rel} (SD)	Mean $\log_{10}$ *a* (SD)	Mean *b* (SD)
Siluriformes/Auchenipteridae											
Centromochlus heckelii (De Filippi, 1853)	81	4.5	11.1	2.1	23.1	0.017 (0.014-0.022)	2.993 (2.856-3.131)	0.98 (0.97-0.99)	1.010 (0.148)	-1.750 (0.047)	3.010 (0.042)
Siluriformes/Doradidae											
Ossancora punctata (Kner, 1855)*	55	3.3	9.1	0.7	12.8	0.022 (0.017-0.028)	2.851 (2.714-2.989)	0.98 (0.97-0.99)	1.008 (0.129)	-1.710 (0.054)	2.880 (0.041)
Siluriformes/Heptapteridae											
Pimelodella cristata (Müller & Troschel, 1849)	49	6.9	18.9	3.5	55.2	0.010 (0.006-0.014)	3.039 (2.864-3.214)	0.98 (0.97-0.99)	1.010 (0.134)	-2.010 (0.040)	3.030 (0.028)
Siluriformes/Loricariidae											
Hypoptopoma elongatum Aquino & Schaefer, 2010*	58	4.2	**10.6**	1.1	24.2	0.009 (0.006-0.012)	3.238 (3.071-3.406)	0.98 (0.97-0.99)	1.011 (0.150)	-2.090 (0.109)	3.070 (0.086)
Siluriformes/Pimelodidae											
Pimelodus blochii Valenciennes, 1840	72	5.1	23.1	1.3	56.8	0.012 (0.009-0.016)	2.838 (2.691-2.986)	0.98 (0.96-0.99)	1.025 (0.202)	-2.000 (0.041)	2.900 (0.030)
Tetraodontiformes/Tetraodontidae											
Colomesus asellus (Müller & Troschel, 1849)	104	3.9	9	0.9	9.9	0.021 (0.017-0.025)	2.819 (2.719-2.919)	0.980 (0.97-0.99)	1.007 (0.123)	-1.480 (0.120)	2.730 (0.129)

N - number of individuals; TL, total length; TW, total weight; LW, length weight; CI, confidence interval; r^2, Pearson r-squared for log–log regression; SD, standard deviation; K_{rel}, allometric condition factor; *a* and *b*, parameters of the relationship. *Species with no record of length-weight relationship. New TL maximum sizes registered for the species in bold type.

for *P. cristata* which obtained positive allometric growth (*b* >3), but with a higher value than that reported for this specie in the current literature (Garcia-Ayala et al., 2014; Cella-Ribeiro et al., 2015; Ferraz and Giarrizzo, 2015; Giarrizzo et al., 2015; Silva et al., 2015).

Prawn fishing mainly affects juvenile and immature individuals because of the small mesh size of its gear, causing a very negative impact on fish size selectivity. These fisheries are currently carried out in a disorderly way, since there is no type of monitoring and control of natural stocks, and prawns of all sizes are caught. Despite receiving the same name, the fishing tackle known as "matapi" (Imbiriba et al., 2020) used in prawn fishing near the city of Santarém, PA, differs from that described and used in other regions of the Amazon basin (Sousa et al., 2014). In other regions, they are made with strips of vegetable fiber that form a cylindrical cage and both ends are tapered to facilitate the entry of the prawn. Babassu (*Attalea speciosa*) flour or cooked fish are often used as baits (Sousa et al., 2014).

Thus, for fisheries management, it would be advantageous to determine the quantity of bycatch of such small-sized specimens in order to be able to assess the impact on the stocks and also develop fishing gear (e.g., large square mesh, escape rings and other exclusion devices) that would allow small fish to escape capture (Eayrs, 2007) and thus favor the other types of fisheries in the Lower Amazon (Imbiriba et al., 2020). This is particularly important since fishery activities and fish species in this region have a strong influence in cultural, economic and ecological aspects for the riverine populations (Garcez et al., 2017).

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