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TECHNICAL CONTRIBUTION

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Length–weight relationships of freshwater fishes of the Alto Madre de Dios River (Manu Biosphere Reserve, Peru)

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Summary

The present work provides the estimates of morphometric relationships for 22 native freshwater fish species (11 Characidae, five Loricariidae, two Heptapteridae, one Astroblepidae, one Crenuchidae, one Curimatidae and one Erythrinidae) collected in the Alto Madre de Dios River (Cuzco and Madre de Dios, Peru) in June 2012 using a mobile backpack electrofishing unit. These are the first length–weight relationships reported for 24 species, mostly endemic to the Amazonian basin. Knowledge regarding these biometric relationships can be relevant in the management and conservation of the local fishes and fisheries.

1 | INTRODUCTION

Fish length is often more rapidly and easily measured than weight in field surveys of freshwater fishes; determination of the biomass is useful where only the length is available. In addition, this type of data and information are needed to analyze fish distributions, which are the most important biological parameters for management and conservation of the populations of native species (Hossain et al., 2012).

Few LWRs are known for those fishes that have no prominent commercial interest and which were once restricted to remote areas (Gaspar, Tobes, Miranda, Leunda, & Peláez, 2012). This could be the case in the Andean Amazon, where inland freshwater fisheries are a relevant resource from the point of view of both commercial and subsistence fishing. The fisheries trade is carried out predominantly by urban-based professional fishermen, whereas in remote and sparsely populated areas local subsistence fishing is carried out by rural residents (Almeida & Lorenzen, 2003).

The Amazon Basin hosts the greatest richness of freshwater fish species in the world (Thieme et al., 2007). With many new species described every year, Peru is acknowledged as being one of the 10 most biologically diverse countries in the world, with an extremely high freshwater fish diversity of 1,064 reported species, the majority of which inhabit the Amazon (Ortega et al., 2012).

Our study estimated the length–weight relationships of 22 fish species captured in ecological surveys in the Alto Madre de Dios River on the Peruvian Andean-Amazon piedmont, as a first approach to the study of the biology of the fish species in this remote area. Of this group of fishes, none had been evaluated or included in the IUCN Red List of Threatened Species (IUCN, 2015), and with an almost complete lack of knowledge regarding their biology. A taxonomic description is the only information available for most of these species.

2 | MATERIAL AND METHODS

The study was conducted on the southern buffer zone of the Manu Biosphere Reserve, in the Alto Madre de Dios Basin (11°00′–13°30′S; 73°30′–68°30′W). The river flows south to north for 275 km through the rainforest of the Cusco and Madre de Dios departments, draining an area of approximately 1,600 km^2. The altitude varies from more than 2,700 to 300 m a.s.l. in the Manu River junction. The fishes were collected using a mobile backpack electrofishing unit (300–600 V, 0.2–2 A; IG200, Hans Grassl GmbH, Schönau, Germany) at different sampling sites in June 2012.

The collected fishes were anesthetized and subsequently measured to the nearest 0.1 cm total length (TL), weighed on a digital scale to an accuracy of 0.01 g and released after the survey. Some voucher

TABLE 1 Length–weight relationships of 22 freshwater fish species caught in Alto Madre de Dios River (Manu Biosphere Reserve, Peru)

Species	*TL* class	*n*	*a*	95% CL of *a*	*b*	95% CL of *b*	r^2
Astroblepus mancoi	2.2–**10.2**	40	0.0079	0.0042–0.0152	3.126	2.807–3.421	.96
Astyanax bimaculatus	3.2–11.3	73	0.0075	0.0063–0.0090	3.234	3.115–3.347	.97
Astyanax maximus	3.2–**14.6**	20	0.0067	0.0051–0.0091	3.251	3.075–3.393	.98
Bryconamericus diaphanus	3.5–**13**	55	0.0076	0.0043–0.0132	3.146	2.890–3.410	.97
Bryconamericus pectinatus	4–**8**	62	0.0073	0.0068–0.0326	3.329	3.146–3.521	.92
Ceratobranchia binghami	2.6–**6.2**	134	0.0082	0.0068–0.0104	3.160	2.999–3.292	.94
Creagrutus muelleri	2.9–5.7	20	0.0085	0.0069–0.0105	3.078	2.933–3.213	.99
Creagrutus ungulus	3.8–**10.9**	21	0.0124	0.0088–0.0192	2.925	2.730–3.088	.99
Creagrutus yanatili	2.5–**10**	66	0.0070	0.0058–0.0079	3.217	3.152–3.312	.99
Knodus geryi	3.2–6.6	62	0.0110	0.0074–0.0173	2.950	2.687–3.182	.94
Knodus hypopterus	2.6–**5.8**	14	0.0114	0.0068–0.0326	2.907	2.259–3.215	.95
Moenkhausia oligolepis	3.1–9	61	0.0073	0.0050–0.0107	3.363	3.152–3.562	.97
Characidium zebra	4–**6.9**	16	0.0040	0.0020–0.0061	3.399	3.150–3.762	.98
Steindachnerina guentheri	3.9–10	9	0.0087	0.0045–0.0153	3.145	2.837–3.518	.98
Hoplias malabaricus	5.4–21.2	15	0.0063	0.0049–0.0090	3.115	2.961–3.213	.99
Chasmocranus quadrizonatus	4.4–**6.3**	7	0.0093	0.0017–0.0178	2.899	2.503–3.771	.97
Rhamdia quelen	8–22.7	15	0.0055	0.0038–0.0074	3.101	2.988–3.247	.99
Chaetostoma lineopunctatum	1.9–11.1	46	0.0149	0.0128–0.0177	2.984	2.888–3.077	.99
Chaetostoma marcapatae	2.4–12.4	136	0.0143	0.0116–0.0173	2.942	2.821–3.073	.96
Crossoloricaria rhami	4.6–11.2	23	0.0028	0.0015–0.0063	3.195	2.830–3.494	.97
Hypostomus oculeus	2.9–7.7	6	0.0146	0.0073–0.0209	2.722	2.388–3.238	.99
Rineloricaria lanceolata	4.8–**12.3**	23	0.0013	0.0009–0.0024	3.444	3.201–3.640	.98

n, sample size; *L* class, length class (cm); *a* and *b*, parameters of the equation; CL, confidence limits; r^2, coefficient of determination.
Species in bold: no LWR parameters in FishBase (Froese & Pauly, 2015). Maximum lengths data in bold: data. Total length (TL) measured to nearest 0.1 cm; body weight measured to an accuracy of 0.01 g.

specimens were kept for identification, preserved in alcohol (75%) in the laboratory, labeled and stored in the fish collection of the museum. Scientific names were validated according to the Catalog of Fishes of the California Academy of Sciences (Eschmeyer & Fricke, 2015).

The parameters of LWRs were estimated using the allometric model as $W = a \times TL^b$, where *W* is the total body weight (expressed in grams), TL is the total length (expressed in centimeters), *a* is the intercept and *b* the slope of the regression line. Prior to regression analysis, plots of *W* and TL were used to detect and exclude outliers (Froese, 2006). Only extreme outliers attributed to data error were omitted from the analyses. The 95% confidence limits (CL) of *b* were calculated (Zar, 1999) to estimate differences between calculated slopes and those reported in the FishBase database (Froese & Pauly, 2015). Statistical analyses were performed using the PAST software package (Hammer, Harper, & Ryan, 2001).

3 | RESULTS

A total of 924 specimens belonging to seven families and 22 species were analyzed: 11 Characidae, five Loricariidae, two Heptapteridae, one Astroblepidae, one Crenuchidae, one Curimatidae and one Erythrinidae. Results of the regression analyses along with the descriptive statistics are shown in Table 1. All regressions were highly significant ($p < .001$), with r^2 values greater than .92. For 16 of the 22 species the LWRs were previously unknown in the FishBase database (Froese & Pauly, 2015). This study also provides new maximum sizes for 11 of the studied species (Table 1).

4 | DISCUSSION

The high number of new LWRs for 16 species and maximum sizes recorded for 11 species supports and confirms the presumption that knowledge on Andean Amazon fishes is poor and scarce.

Differences in *b* values were found in only three of the species. The slope *b* of the *Astyanax bimaculatus* population was higher than estimated for this species in Itaipu Reservoir, Paraná, Brazil (Benedito-Cecilio, Agostinho, & Velho, 1997). The *b* value obtained for the *Characidium zebra* population was higher than estimated for this species in the Taquari River, Paranapanema Basin, Brazil (Nobile et al., 2015). Lastly, the b slope of the *Rhamdia quelen* population was higher than estimated for this species in the Santa Lucía River basin, Canelones-Montevideo, Uruguay (Teixeira-de Mello, Vidal, Eguren, & Loureiro, 2009).

These differences in *b* values can be attributed to a combination of one or more factors including: habitat, area, seasonal effect, degree of stomach fullness, gonad maturity, sex, health, preservation techniques, and differences in the observed length ranges of the captured specimens (Hossain et al., 2012, 2015; Miranda, Galicia, Monks, & Pulido-Flores, 2009).

These results are useful for further studies and for other key parameters necessary for fisheries management. They can also serve as baseline data for species with no previous length–weight relationships as well as for comparisons with future studies of Andean Amazon freshwater fishes.

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