



Length-weight relationships of three threatened seahorse species (Syngnathidae: Hippocampus) along the Brazilian coast

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Abstract: This study estimates the length-weight relationships (LWR) of three threatened seahorse species along the Brazilian coast. The analysis includes data on both sexes and aggregated individuals.

Key words: morphometry, fish biometrics, Syngnathiformes, marine fish.

Relação peso-comprimento de três espécies de cavalos-marinhos ameaçadas (Syngnathidae: Hippocampus) ao longo da costa brasileira. Resumo: Relações de peso-comprimento foram estimados para três espécies de cavalos-marinhos ameaçadas, na costa Brasileira. As análises foram realizadas separadamente por sexo e com todos os indivíduos juntos.

Palavras-chave: morfometria, biometria de peixes, syngnathiformes, peixes marinhos.

Length–weight relationships (LWR) are an important tool for supporting fish biology studies and, when combined with other regularly monitored parameters, contribute to the development of fishery management plans (Oliveira *et al.* 2015). According to Froese (2006), LWRs can provide information on fish condition, determine isometry or allometry of somatic growth, and compare growth patterns among species across different regions.

On the Brazilian coast, there are three seahorse species: *Hippocampus reidi* Ginsburg, 1933, *Hippocampus patagonicus* Piacentino & Luzzatto, 2004, and *Hippocampus erectus* Perry, 1810. These species range from Cape Hatteras, United States, to Rio Grande do Sul, Brazil, and Argentina (Lourie 2004, Piacentino & Luzzatto, 2004, Silveira *et al.* 2014). Seahorses are commonly associated with mangrove roots, coastal reefs, seagrasses, and macroalgae (Lourie 2004). In Brazil,

seahorse species are intensively exploited through incidental capture in shrimp trawling, exposure to sun and drought, and sale as ornamental items or medicine (Di Dario *et al.* 2018a, 2018b, Silveira *et al.* 2018). Due to these threats, which cause population declines and habitat destruction, *H. patagonicus* and *H. erectus* are currently categorized as Vulnerable, and *H. reidi* as Near Threatened according to the IUCN Red List of Threatened Species (IUCN 2016).

We investigated the LWR of three seahorse species within the genus *Hippocampus* to provide basic morphometric information for further biological studies of these species.

H. reidi was sampled in the estuary of the Maracaipe River, located in the State of Pernambuco, Brazil (8°32'20.93" S, 35°0'31.38" W). *H. erectus* specimens were collected on Porto de Galinhas beach, Pernambuco State (8°30'55.28" S,

35°0'12.54" W) (Figure 1). These individuals were manually collected and transported alive to the laboratory for morphometric measurements before being returned to the collection site. Specimens of *H. patagonicus* were collected as bycatch from shrimp fishing along the Rio de Janeiro coast, between 23°16'31.94" S, 44°27'28.70" W and 21°56'23.10" S, 40°28'24.82" W (Fig. 1). These trawl-caught individuals were preserved in 90% ethanol before laboratory analysis.

For *H. patagonicus*, males are characterized by an average height of brood pouch formation of 4.7 cm (Silveira et al. 2020). Animals with greater heights and without a brood pouch were classified as females. Fish that presented a brood pouch at any time were classified as males. For *H. reidi*, with an average height of brood pouch formation of 10.0 cm, sizes greater than 10.0 cm and without a brood pouch were considered females; for *H. erectus*, with a height of brood pouch formation of 6.0 cm, individuals with heights greater than this and

without a brood pouch were classified as females (Silveira et al. 2016, Silveira & Silva 2016). Total weight (TW) was measured in grams using a digital scale with 0.01 g precision, and total height (TH), defined as the linear measurement from the top of the head to the tip of the extended tail, was measured in centimeters using a digital caliper with 0.1 cm precision.

LWR parameters were determined using the linear regression model: $\log TW = \log a + b \log HL$, where "a" is the intercept and "b" is the slope of the linear regression (Froese 2006). Before regression analyses, length-weight plots were examined to eliminate outliers (Froese 2006). The analysis was performed separately by sex, with all individuals combined where necessary. Due to the low number of individuals, the analysis for *H. erectus* was conducted without separation by sex. The analyses were conducted using the R software (R Core Team 2020).



Figure 1. Map of the Brazilian coast showing the study sites for each seahorse species. Black circle indicates the location for *Hippocampus patagonicus*, and red circles denote the locations for *Hippocampus reidi* and *Hippocampus erectus*.

Table I. Descriptive statistics and estimated parameters of the length-weight relationship (LWR) for three seahorse species along the Brazilian coast (Syngnathiformes: Syngnathidae: *Hippocampus*). TH = total height, TW = total weight, N = Number of individuals, R^2 = regression coefficient, a = intercept of the linear regression, b = slope of the linear regression.

Species	Sex	N	TH (cm)	TW (g)	R^2	a	a _{IC95%}	b	b _{IC95%}
<i>H. reidi</i>	Female	158	10.1-7.7	3.41-22.53	0.826	0.005	0.003-0.007	2.893	2.754-3.031
	Male	168	6.7-17.7	1.40-22.53	0.924	0.002	0.002-0.003	3.156	3.030-3.282
	All	326	6.7-17.7	3.41-22.53	0.863	0.004	0.003-0.005	2.996	2.896-3.095
<i>H. patagonicus</i>	Female	222	5.6-14.2	0.36-12.28	0.950	0.002	0.001-0.002	3.179	3.070-3.287
	Male	409	6.5-15.9	0.94-17.84	0.951	0.003	0.002-0.003	3.049	2.964-3.134
	All	673	5.6-15.9	0.36-17.84	0.950	0.002	0.002-0.003	3.069	2.986-3.151
<i>H. erectus</i>	All	14	4.7-13.0	0.22-06.68	0.985	0.001	0.000-0.002	3.286	3.047-3.525

All LWR parameters were significant ($p < 0.00001$), with r^2 values ranging from 0.83 to 0.98 (Table I). The parameter b values (>3) indicated positive allometric growth for *H. patagonicus* and *H. erectus* (Froese 2006). *Hippocampus reidi* exhibited negative allometric growth (<3) when all individuals were analyzed together. For *H. reidi*, the growth type varied by sex: females had lower b values, indicating negative allometric growth, while males had positive allometric growth.

The results obtained here differ from LWR values reported for other *Hippocampus* species. Baştusta et al. (2014) and Veiga et al. (2009) found negative allometric coefficient values for *Hippocampus hippocampus* and *Hippocampus guttulatus* (2.64 and 2.84, respectively). Park and Kwak (2015) also found negative allometric growth for *Hippocampus coronatus*. Ben Amor et al. (2011) reported isometric growth for *H. hippocampus* and *H. ramulosus* (3.06 and 3.01, respectively). Despite these differences, the values found in this study fall within the expected range for Osteichthyes (2.5-3.5) (Froese 2006) and other seahorses (2.47-3.14) (Gurkan & Taşkavak 2007, Ben Amor et al. 2011, Park & Kwak 2015, Ak & Kutlu 2009).

It is important to note that *H. patagonicus* specimens may have experienced shrinkage due to dehydration from preservation in 90% ethanol before morphometric analysis. Therefore, the LWR parameters should be considered provisional until a correction factor for shrinkage is established (Buchheister & Wilson 2005, Nordeide 2020).

In summary, this study provides valuable morphometric information on three seahorse species. This information supports future biological research and conservation planning for these vulnerable species. The data presented can be compared with similar studies in Brazilian bays and estuaries and will be useful in areas where seahorse populations

are impacted by commercial fishing, including recovery programs and other management and conservation activities.

Ethical statement

Animal collection and handling procedures were carried out in accordance with current international and national standards, considering animal welfare, under SISBIO authorization No. 53352-5.

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