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Research Article

Length–Weight Relationships of Elasmobranchs Caught by Artisanal Fisheries From Southern Gabon

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Establishing length–weight relationships (LWRs) is essential for conserving fish populations, especially where gaps hinder efforts, particularly crucial for elasmobranch populations in the Gulf of Guinea. This study presents LWRs established for six species of elasmobranchs landed by artisanal maritime fishing in Mayumba, located in the south of Gabon. The data were collected in May 2022 and between September 2022 and March 2023. This work provides the first LWRs for six elasmobranch species that have not yet been referenced at the regional level. One of these species, *Paragaleus pectoralis*, lacks referenced data on FishBase.

Keywords: elasmobranch species; Gabon; length–weight relationships

1. Introduction

Sharks and rays (elasmobranchs), as predators, play a crucial role in marine ecosystems [1]. However, due to overfishing, an estimated 37.5% of species are now listed as threatened on the IUCN Red List [2]. Their slow growth and late maturation make them more susceptible to overexploitation compared to teleost fish [3].

Understanding fish dynamics and growth patterns is essential for developing effective conservation and fisheries management strategies to protect threatened species and ensure their long-term survival. However, knowledge gaps in length–weight relationships (LWRs) can impede accurate stock assessments [4]. These relationships are critical in fisheries science, as they enable researchers to estimate biomass from landings data, even when only length measurements are available. This is particularly useful in field studies where weighing individual elasmobranchs is impractical, such as at crowded landing sites [5]. In such cases, length data can be more accessible and provide a reliable basis for converting into weight, improving biomass estimates [6].

In Gabon and Central Africa, a lack of understanding of allometric relationships within elasmobranch populations exacerbates the regional knowledge gap concerning fish populations in the Gulf of Guinea [7]. This data deficiency complicates fisheries management [8], limiting our ability to assess which size classes of elasmobranchs are destined for local consumption or sale, and preventing us from identifying species-specific vulnerabilities to fisheries. Furthermore, it challenges the implementation of sustainable practices, such as size-based landing restrictions or spatial protection for individuals at vulnerable life stages.

To address these gaps, this study specifically aims to improve biomass estimation of landed elasmobranchs by establishing accurate LWRs for six species in Central Africa. This enhanced understanding contributes to better stock assessments and more effective fisheries management strategies.

2. Materials and Methods

Elasmobranchs were collected in May 2022 and between September 2022 and March 2023 at the artisanal maritime fishing landing sites in Mayumba (3.43°S, 10.66°E), located on the southern coast of Gabon. Elasmobranch captures from this fishery are predominantly by-catches, target species being mainly bony fish. Bottom gillnets, and occasionally surface gillnets, were used, with mesh sizes ranging from 45 to 50 mm, and nets measuring approximately 3 km in length and 1.5 m in height.

All landed elasmobranchs were identified to the species level, referring to various identification guides [9–13]. Maturity stages were determined by examining clasper development in males (juveniles had short, flexible claspers, while adults had long, calcified claspers). Female maturity was inferred by referring to Compagno [9] for sharks and Séret [13] for rays, based on the size of first maturity described in these works. Subsequently, their total length (TL, expressed in cm) was measured in their normal posture, and their weights (W, expressed in grams) was recorded.

Data points that significantly deviated from the overall trend, based on their residuals, were considered outliers and excluded from further analysis [14]. The LWR was established using the following equation:

$$W = a \times \mathrm{TL}^{b}, \quad (1)$$

where W represents fresh weight in grams and TL represents total length in cm [4, 15, 16]. The parameters "a" and "b" correspond to the intercept and regression coefficient, respectively [4]. Each element of Equation (1) was estimated using the least squares adjustment method, employing the following equation [4, 17]:

$$\log W = \log a + b \times \log \mathrm{TL}. \quad (2)$$

The estimation of r^2 (coefficient of determination) was conducted using the least squares adjustment method in Equation (2) [17]. To assess intraspecific variations in the LWR based on sex, we employed an analysis of covariance (ANCOVA) by species. Length served as a covariate in the analysis [18], and we examined distinctions in the slopes of the LWRs. Only species with more than 12 individuals per sex type were tested for independence between sexes [19].

3. Results

The complete LWR results are summarized in Table 1, which includes sample sizes, minimum and maximum lengths and weights for each species, and the corresponding parameters ("a" and "b") along with their 95% confidence intervals. The coefficient of determination (r^2) for each species is also presented.

Scalloped hammerhead (*Sphyrna lewini*) was the sole species in which we identified a significant difference in the weight–length regression slopes between sexes (ANCOVA, p value = 0.0027). As a result, the LWR for this species were expressed by sex, and both sexes combined. Due to limited data (only six males), sex-specific analysis was not performed for smooth-hound (*Mustelus mustelus*).

The observed species were mainly small, including adults and juveniles of small-sized species such as the milk shark (*Rhizoprionodon acutus*), which also included neonates, as well as the Atlantic weasel shark (*Paragaleus pectoralis*) and *M. mustelus*. Neonates and juveniles of *S. lewini* and the blacktip shark (*Carcharhinus limbatus*) were also present. For blackchin guitarfish (*Glaucostegus cemiculus*), both adults and juveniles were present.

4. Discussion

This study provides the first LWR for *G. cemiculus*, *P. pectoralis,* and *S. lewini* in African coastal waters [20]. Three other species have the LWR available on FishBase [20] for Africa but from very distant systems, such as *C. limbatus* and *R. acutus* in South Africa, and *M. mustelus* in the Republic of Cabo Verde. *P. pectoralis* has no data on FishBase [15].

The high presence of small-sized sharks in the catches is likely due to the coastal nature of artisanal fishing, which may intersect with nursery areas for coastal elasmobranch [21]. This observation could highlight ontogenetic segregation, where juveniles and neonates tend to frequent these coastal habitats for reasons of protection or/and food availability [22]. While mesh selectivity might explain the predominant presence of *C. limbatus*, it is less applicable to *S. lewini*. The large cephalofoil of adults makes them more likely to be caught in smaller mesh sizes [23].

Significant differences in LWR between sexes in *S. lewini* may be due to unequal size distributions between males and females [24] or higher values of the "b" parameter in females, indicating a greater increase in girth compared to length [4].

In this current investigation, the calculated "b" coefficients for all six species stayed within the anticipated scope of 2.5–3.5, as outlined by Froese [4]. *G. cemiculus*, *P. pectoralis*, and female *S. lewini* have "b" values > 3, consistent with the findings by Başusta et al. [14] for *G. cemiculus* and by Motta et al. [25] for *S. lewini*. These results suggest that larger specimens increase in girth rather than in length [4]. *C. limbatus*, *R. acutus*, *M. mustelus*, and male *S. lewini* have "b" values < 3, with similar findings for *C. limbatus* according to Motta et al. [25], but different for male *S. lewini*. Pereira et al. [19] found divergent results for *M. mustelus* where "b" values > 3. For *R. acutus*, Gladston et al. [5] obtained similar results. These "b" values suggest that larger specimens tended to be more elongated, or smaller ones were in better nutritional condition during sampling [4].

Most species exhibited r^2 values in the range of 0.763–0.859. These values may reflect natural variation in body, gear selectivity condition [26], or inadequate representation of size classes [27]. An exception was *P. pectoralis* which, despite having a smaller sample size relative to other

Table 1: Length–weight relationship (LWR) parameters for six elasmobranch species landed by the artisanal marine fishery of Mayumba, Southern Gabon, in May 2022 and between September 2022 and March 2023.

Species	Sex	*n*	Length (cm)	Weight (g)	Relationship parameters		r^2
			Min-Max	Min-Max	a (95% CI)	b (95% CI)	
Carcharhinus limbatus (N, J)	Both	177 (N:67; J:110)	56–123	775–17,200	0.012 (0.005–0.033)	2.837 (2.608–3.065)	0.774
Rhizoprionodon acutus (N, J, A)	Both	243 (N:9; J:178; A:56)	45–102	390–5040	0.042 (0.020–0.087)	2.435 (2.262–2.607)	0.763
Glaucostegus cemiculus (J, A)	Both	41 (J:28; A:13)	79–212	554–32,760	0.001 (0.000–0.008)	3.337 (2.808–3.866)	0.807
Mustelus mustelus (J, A)	Both	38 (J:28; A:10)	56–119	740–6040	0.003 (0.001–0.008)	2.978 (2.570–3.386)	0.859
Paragaleus pectoralis (J, A)	Both	40 (J:11; A:29)	63–125	805–7,200	0.004 (0.001–0.022)	3.202 (2.908–3.496)	0.928
	Male	191 (N:70; J:121)	48–130	260–13,030	0.001 (0.003–0.017)	2.904 (2.675–0.017)	0.767
Sphyrna lewini (N, J)	Female	185 (N:49; J:136)	49–107	330–8660	0.002 (0.000–0.005)	3.173 (2.949–3.397)	0.811
	Both	376 (N:119; J:257)	48–130	290–13,030	0.004 (0.002–0.008)	3.012 (2.851–3.173)	0.782

Note: Both: male and female. The parameter “a” represents the predicted weight of the fish at zero length, reflecting its body condition and morphology. The parameter “b” indicates the growth pattern: $b = 3$ corresponds to isometric growth, $b > 3$ suggests girthier growth, and $b < 3$ reflects more elongated growth [4].
Abbreviations: A, adult; CI, confidence interval; J, juvenile; Max, maximum; Min, minimum; N, neonate.

species in this study, displayed a high r^2 value (> 0.92), likely due to the wide size range included [27].

5. Conclusion

The LWRs established in this study for six elasmobranch species from southern Gabon represent a significant contribution to addressing the regional gap in biometric data for these ecologically and economically important species. These relationships provide a practical tool for fisheries science, enabling more accurate biomass estimations when only length measurements are available, particularly in artisanal fisheries where weighing individuals is often impractical. By supporting the implementation of size-based catch limits, these findings can help ensure that only individuals above a certain length are harvested, thus protecting juveniles and vulnerable life stages. Such measures are essential for promoting sustainable fisheries management, which is increasingly critical given the pressures on marine resources in the Gulf of Guinea.

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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