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Length-weight Relationship of Five Demersal Fish Species in Guinea Bissau (CE Atlantic)

Alba Jurado-Ruzafa[1] · **Carlos Hernández-González**[1]

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Abstract
Length-weight relationships (LWR) were determined for *Brotula barbata*, *Dentex angolensis*, *Dentex macrophthalmus*, *Neomerinthe folgori* and *Scorpaena stephanica* using individual fish records collected between July 2002 and January 2003, during a pilot project of experimental fishing over the shelf off Guinea Bissau. Fishes were caught by commercial vessels using bottom longline, measured defrost for the total length (to the lower 0.1 cm) and weighted for the total weight (TW, to the 0.1 g), and sexed. Two new maximum total lengths were registered for *Scorpaena stephanica* and *Neomerinthe folgori*, whose LWR *b*-values corresponded to the limits of the range obtained, between 2.833 and 3.318, respectively. All LWRs were obtained from well-adjusted linear regressions with $r^2 \geq 0.90$. Data presented herein expand the knowledge base for these species in West Africa, as they have limited or no LWR data available.

Keywords Length-weight relationships · Demersal species · West Africa

Introduction

Fisheries management and research often require the use of biometric relationships to transform data collected in the field into suitable indices (Bilge et al. 2014). The length and weight are relatively easy and low-cost data to measure from fish. Knowledge of the relationships between these two variables for fish species of a certain geographical region is very useful, since it provides the structure of their populations based on their composition in length or weight, and allows the estimation of the weight of a size class and/or age of the catch (Anderson and Gutreuter 1983). Therefore, length-weight relationships (LWR) represent one of the most useful and used life history traits because they allow to estimate biomass based on the length of individuals (Gulland 1983; Holden and Raitt 1975). Hence, when one fish stock is in consideration, the more accurate is this information, the more reliable will be the assessment results.

Guinea-Bissau Exclusive Economic Zone (between 08° 38' 21" N and 12° 24' 48.7" N, 14° 49' 21.9" W and 19° 48' 15" W [FMI 2019]) belongs to a country in West Africa very dependent on its natural resources, with fisheries being one of the main economic activities (Dia 2001), including foreign industrial fleets which mainly target demersal species (FAO 2015; RCG LDF 2022). In the absence of a regular monitoring system for fisheries in Guinea Bissau, only sporadic and intermittent national surveys or in collaboration with the Spanish Government have been performed in the region, following the scientific recommendations (Intchama et al. 2018; Sobrino et al. 2022). Likewise, an increasing interest on the area is reflected on the FAO EAF-Nansen Programme (https://www.fao.org/in-action/eaf-nansen/), or the EU DEMERSTEM project (which aims to improve scientific advice production on shared demersal stock in West Africa) (http://pescao-demerstem.org/).

During last decades, different initiatives have been performed to evaluate the profitability of the fishing activity in the area, including a pilot project of experimental fishing in 2002–2003 coordinated by the Oceanographic Centre in the Canary Islands (Spanish Institute of Oceanography - IEO, CSIC), which have contributed to increase the knowledge on these caught species, including the estimation of their length–weight relationships as useful information to estimate fish biomass based on length samplings. From a

✉ Alba Jurado-Ruzafa
alba.jurado@ieo.csic.es

[1] Centro Oceanográfico de Canarias, Instituto Español de Oceanografía (IEO, CSIC), C. Farola del Mar n. 22 (38180), Santa Cruz de Tenerife, Spain

practical point of view, at present, few information on this trait of the existing fish species has been published ad hoc in the area (Correia et al. 2018). Hence, researchers and fishery assessors working in Guinea Bissau may take advantage of the information here presented.

Materials and Methods

Fish analyzed in the present study was collected by fishing operations carried out by professional fishermen following the scientific design on board of three different commercial vessels (see Fig. 1), under the pilot project "Experimental fishing in waters off Guinea Bissau" (RAI-AP-03/2002)", from July 2002 to January 2003. Bottom horizontal longlines used were the 'Spanish-type' or double line, armed with a "tether line" and a "fishing line" from which the hooks hang. Depending on the type of bottom and the species targeted, the latter could be Coral-type (polyethylene) or nylon made, armed with 60 to 100 hooks by longline section (both hooks 'parrot beak' -hook sizes 3/0 and 4/0- and 'ancora' hooks -numbers 6 and 7-) for each 100-meter-long gear. The baiting of the longlines was done manually and the bait used consisted of sardines, chub mackerel and, to a lesser extent, horse mackerel. The EFT was 1.5-4 h.

After the taxonomical identification, individuals of the target and by-catch species were selected by length classes to complete the length range available, which were kept frost to be carefully analyzed in the Oceanographic Centre in the Canary Islands, based in Tenerife. All the specimens were confirmed for the species and, then defrosted and measured for the total length (TL, to the lower 0.1), weighted for the total weight (TW, to the 0.1 g) and sexed macroscopically, when possible.

Length–weight relationships (LWR) were estimated using the log-transformation ($\log TW = \log a + b \times \log TL$)

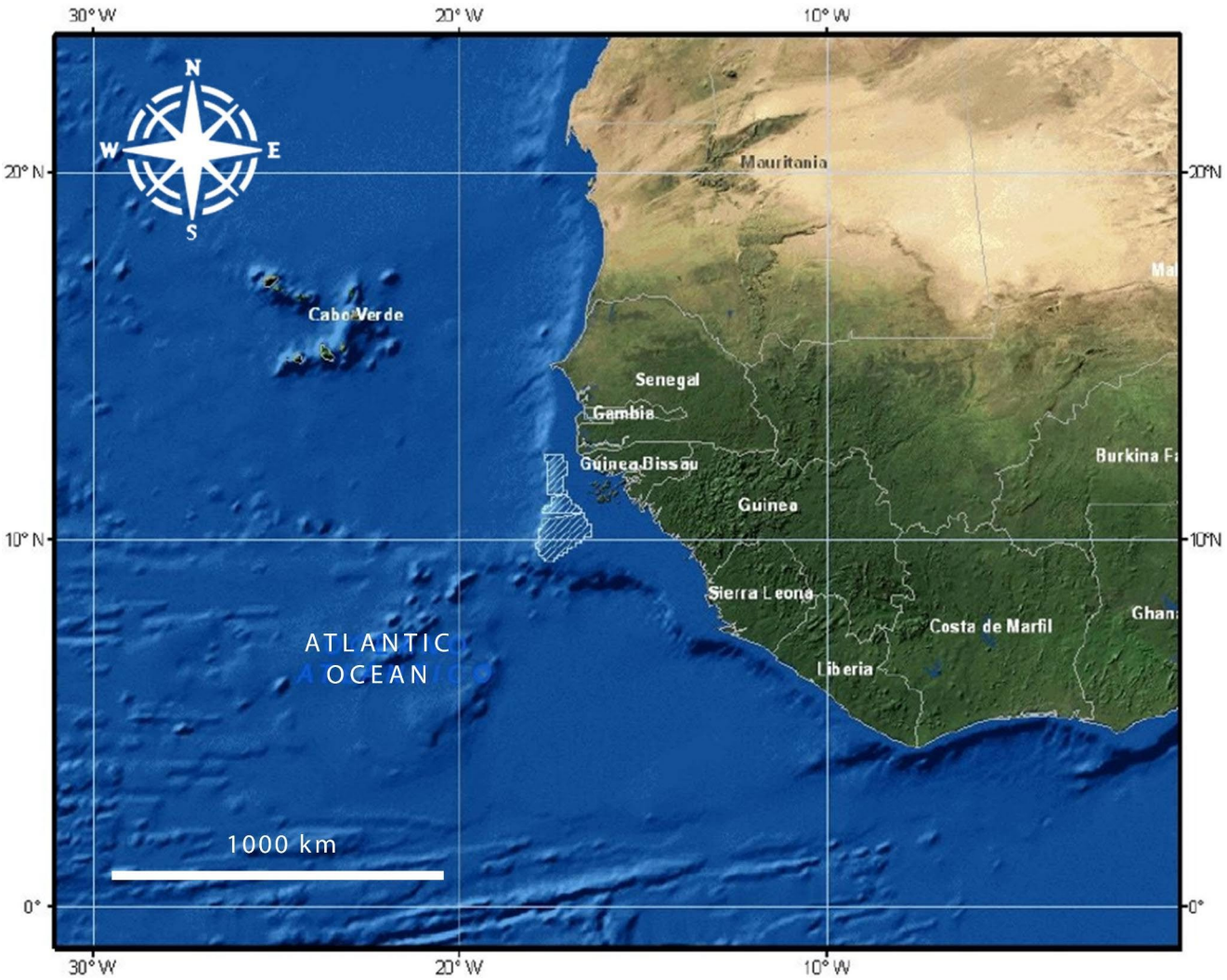

Fig. 1 Map of the study area off Guinea Bissau (West Africa). Highlighted polygons indicate the fishing area allowed to the vessels involved in the pilot project of experimental fishing

of the power formula: $TW = a \times TL^b$, where a is the condition factor (related to body shape) and b is the allometry coefficient (related to the growth pattern) (Pauly 1984). The 95% confidence interval and the standard error were also estimated for the LWR coefficients.

Results

The presented species have limited reference LWRs in the FishBase database, with no references for Guinea Bissau, or any in the case of *S. stephanica* (Froese and Pauly 2023). All the results for the specimens analyzed and the LWRs obtained are presented in Table 1. Linear regressions provided suitable adjustments ($r^2 \geq 0.90$). Based on the available information included in FishBase, two new maximum TLs were registered for *Scorpaena stephanica* and *Neomerinthe folgori*, whose LWR *b*-values corresponded to the limits of the range obtained in the present study, with the *b*-value varying from 2.833 to 3.318, respectively.

Discussion

The present study provides LWRs information for five deep-water demersal species inhabiting Guinean Bissau waters. Based on the information shared in FishBase, only one reliable LWRs exist for *Brotula barbata*:, estimated by using a 100-individuals' sample from Cape Verde, including a narrower size range, mainly in the inferior limit (38.8–68.7 cm). However, the LWR obtained is quite similar to the results in the present analysis. Regarding *D. angolensis*, LWRs available were estimated using furcal lengths of fish collected in Mauritania or southern populations from the Gulf of Guinea, what make the results not comparable since the reference length change the LWR estimated parameters. Sample size was smaller in previous studies and, again, when the size range is provided, it was narrower than the length range used in the present study. Concerning *D. macrophthalmus*, some LWRs were obtained off Cape Verde, but also for Mediterranean populations, Morocco and Mauritania. Although similar size ranges were used, the LWR parameters differ from the ones presented here. In the case of *N. folgori*, only one LWR for Cape Verde exist in the database; but it was based on 49 individuals ranging from 34.0 to 59.0 cm, in contrast with the 289 specimens' sample between 21.9 and 64.1 cm analysed in this work. Moreover, this size range includes the maximum total length reported for the species. Finally, this is the first estimate of LWR for *S. stephanica* including the maximum total length reported for the species (Froese and Pauly 2023).

Although most of studied species are commonly target species or caught as by-catch by commercial fleets, the only genus included in the assessment framework of the area is *Dentex* (FAO 2015). The LWRs determined here will be useful for future status assessment of these exploited and/or discarded species, since not enough reliable LWRs were available for them in the FishBase database (Froese and Pauly 2023) or in other published studies in Guinean Bissau waters (Correia et al. 2018). Indeed, many of the LWRs available on Fishbase are based on small sample sizes and/or limited length ranges. It is well known that the obtention and use of the specific stock's life history traits is used to describe the population geographical structures of species, due to they reflect genetic or environmental differences (Begg et al. 1999; Begg 2005). Regarding size ranges, since fishing was performed using commercial gears, small individuals were not available in some cases, but size ranges included the most common lengths in commercial and by-catch landings, in representative sample sizes. Therefore, the information provided here will allow the assessors to assay more reliable stock assessments of the biomass of these species, by converting length samplings obtained in the region into biomass (Froese 2006).

Describing the growth patterns based on the allometry type would be misleading due to two main limitations of the sampling design. On one hand, small sizes are not present in the samples because of the use of selective commercial fishing gears. On the other hand, samples only corresponded to a time period of 6 months. These limitations prevent discussing the growth pattern, due to it is well known that the energy investment for the somatic growth is strongly related to the sex and reproduction cycles (gonad maturity), very dependent on the seasonality, and year-round cycle individuals were not present in the sample (Wootton 1998). Likewise, other factors which strongly influence the LWRs parameters, such as health or condition of the fish, geographic or seasonal variations in the environmental conditions and differences in the size ranges of the sampled specimens (Casselman 1987; Froese 2006; Jurado-Ruzafa et al. 2016), could not be assessed in the present analysis.

To conclude, it seems necessary to use standardized methodologies (such as the same length measure, among others) agreed among the institutions involved in fishery research in the region to be able to update and to monitor potential spatial and/or temporal variations, and these results constitute important basic information for managers in an area little studied, with increasing fishing interest.

Table 1 Length-weight relationships (LWR) for 5 fish species from Guinea Bissau (Central-East Atlantic). Study time period: July 2002-January 2003. Equation used: $TW = a \times TL^b$. N: sample size; TL: total length; TW: Total Weight; *a* and *b*, LWR parameters; SE: standard error; CI: 95% confidence interval; r^2: determination coefficient; † Maximum TL reported; ‡ Species with commercial interest; * tentative estimate (small size classes missing); ¥ no LWR data on FishBase (Froese and Pauly 2023)

Order	Family	Species	N	TL range (cm)	TW range (g)	*a*	*a* CI SE	*b*	*b* CI SE	r^2
Ophidiiformes										
	Ophidiidae	*Brotula barbata* ‡* (Bloch & Schneider, 1801)	317	29.9–66.3	158.3-2512.8	0.003	0.002–0.004 0.079	3.262	3.169–3.355 0.047	0.94
		Females*	199	29.9–66.3	158.3-2512.8	0.003	0.001–0.005 0.131	3.277	3.122–3.432 0.078	0.90
		Males*	111	31.0-65.1	197.9-2419.1	0.003	0.002–0.004 0.078	3.249	3.157–3.340 0.046	0.98
Perciformes										
	Sparidae	*Dentex angolensis* ‡ Poll & Maul, 1953	769	16.2–37.5	66.0-803.6	0.016	0.014–0.018 0.028	2.973	2.935–3.012 0.020	0.97
		Females	414	16.2–36.9	66.0-798.1	0.014	0.011–0.017 0.045	3.014	2.951–3.076 0.032	0.96
		Males	345	16.2–37.5	71.6-803.6	0.018	0.015–0.021 0.037	2.937	2.887–2.988 0.026	0.97
		Dentex macrophthalmus ‡ (Bloch, 1791)	395	16.5–35.3	54.1-661.4	0.008	0.007–0.010 0.041	3.193	3.136–3.249 0.029	0.97
		Females	250	17.5–35.3	68.6-661.4	0.008	0.006–0.011 0.056	3.200	3.122–3.278 0.040	0.96
		Males	140	16.5–33.0	54.1-621.8	0.008	0.006–0.011 0.056	3.193	3.114–3.271 0.040	0.98
	Scorpaenidae	*Neomerinthe folgori* †‡* (Postel & Roux, 1964)	289	21.9–64.1	160.1–5060.0	0.005	0.004–0.006 0.052	3.318	3.255–3.381 0.032	0.97
		Females*	130	30.0-60.4	302.7–4786.0	0.004	0.003–0.006 0.090	3.369	3.260–3.478 0.055	0.97
		Males*	151	21.9–64.1	160.1–5060.0	0.005	0.004–0.007 0.064	3.301	3.224–3.379 0.039	0.98
		Scorpaena stephanica †‡¥ Cadenat, 1943	810	13.9–41.8	35.3-1013.5	0.026	0.023–0.029 0.023	2.833	2.801–2.864 0.016	0.97
		Females	312	14.1–39.7	36.7-1013.5	0.018	0.015–0.022 0.042	2.954	2.894–3.014 0.031	0.97
		Males	489	13.9–41.8	35.3–975.0	0.024	0.021–0.027 0.028	2.851	2.813–2.890	0.98

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Authors' Contributions Both authors analysed the data and wrote the main manuscript text and table.

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Data Availability Data Availability on request from the authors.

Declarations

Competing Interests The authors declare no competing interests.

Ethical Approval This research was not covered by any regulation and formal ethical approval was not required. The scientific design was approved by the Spanish Fishery Office belonging to the National Government of Spain.

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