Biometric study of the royal sea cucumber, *Parastichopus regalis* (Cuvier, 1817), from Algeria's west coast

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Abstract

The exploitation of sea cucumbers in Algeria began about 10 years ago, although it does not involve *Parastichopus regalis*, which is considered to be bycatch by professional fishermen despite its availability and its very high nutritional and economic value. The objective of this study was to determine some biometric relationships of *P. regalis* that can be used for managing its fishery before its launch. For this, 65 individuals were collected from 9 stations – corresponding to five regions of the Algerian west coast – and were measured and weighed. *Parastichopus regalis* presents a length-weight relationship of $W=0.429L^{1.784}$ considering the measured length and $W=0.371Le^{1.836}$ using the length estimated from the SLW index, which takes into account the length and width of individuals.

Keywords: sea cucumber, length-weight relationship, slw index, estimated length-weight relationship, Algeria

Introduction

In Algeria, the sea cucumber fishery is authorised but not their marketing. Exploitation began in 2013, and individuals are most often harvested by hand, snorkeling and sometimes by scuba diving then destined for illegal export (Mezali and Slimane-Tamacha 2020). However, this fishery does not target the species *Parastichopus regalis*, which is considered as bycatch and discarded at sea. This is done despite its availability along the Algerian coast, its nutritional quality suitable for human consumption, and its economic value (Ramón et al. 2010; Santos et al. 2015; Roggatz et al. 2018; Khodja et al. 2021; Khodja and Mezali 2022). These factors mean that the fishery of this species is promising, and must be launched by the authorities of fisheries sector, but not before measures for its management and sustainable exploitation are undertaken. This study aims to contribute to the knowledge of some biometric parameters of *P. regalis* that can be used for managing this fishery.

Methodology

The sampling of *P. regalis* was carried out at nine stations on the west coast of Algeria. In total, 65 individuals were collected from trawler bycatch (Fig. 1A and 1B) between June 2019 and January 2020 (Table 1). Each individual was measured (contracted length and width) with a tape measure (± 0.1 cm) and weighed on a balance (± 0.001 g). The thickness of the body wall was measured with a caliper (± 0.01 mm). A comparison of length and weight as a function of depth was performed using the Kruskal-Wallis H test because the data were not parametric. Dunn's multiple comparison post hoc test was used to determine the source of the significant differences.

Biometric relationships

The length (L) and width (l) of the individuals are related by a linear relation (Y= bX + a). The linear trendline was used to determine the regression coefficient "b" and the

Table 1. Characteristics of *Parastichopus regalis* sampling stations.

Stations	Geographic coordinates	Depth (m)	No. of individuals
Bahara Mostaganem	36°27.978'N, 0°38.431'E	73	21
Kharrouba Mostaganem 1	35°59.109'N, 0°01.089'E	68	3
Kharrouba Mostaganem 2	36°02.611'N, 0°01.823'W	117	5
Kharrouba Mostaganem 3	36°05.077'N, 0°00.490'E	225	13
Arzew	35°55.443'N, 0°16.166'W	77	12
Bouzedjar	35°38.068'N, 1°08.766'W	96	7
Beni-Saf 1	35°20.186'N, 1°21.456'W	36	1
Beni-Saf 2	35°25.160'N, 1°29.428'W	125	1
Ghazaouet	35°11.392'N, 2°05.491'W	113	2

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intercept "a". The isometry hypothesis (b = 1) was verified by the Student's t-test.

Length-weight and estimated length-weight relationships

To avoid deviations from accurate sea cucumber measurements due to body wall elasticity, the method described by Yamana and Hamano (2006) was used to obtain a more accurate size. This method combines length and width to produce the SLW index, which is the square root of the length multiplied by the width (SLW=√length X width). Subsequently, the recalculated body length (Le) was estimated using the regression between L vs SLW, according to the following equation: Le = bSLW + a (Yamana and Hamano 2006; Poot-Salazar et al. 2014; Siddique and Ayub 2019). The length-weight relationships were estimated using the equation $Y = aX^b$, where "a" and "b" are coefficients, X is the length (L or Le), and Y is the weight (W). The isometry hypothesis (b = 3) was verified by the Student's t-test.

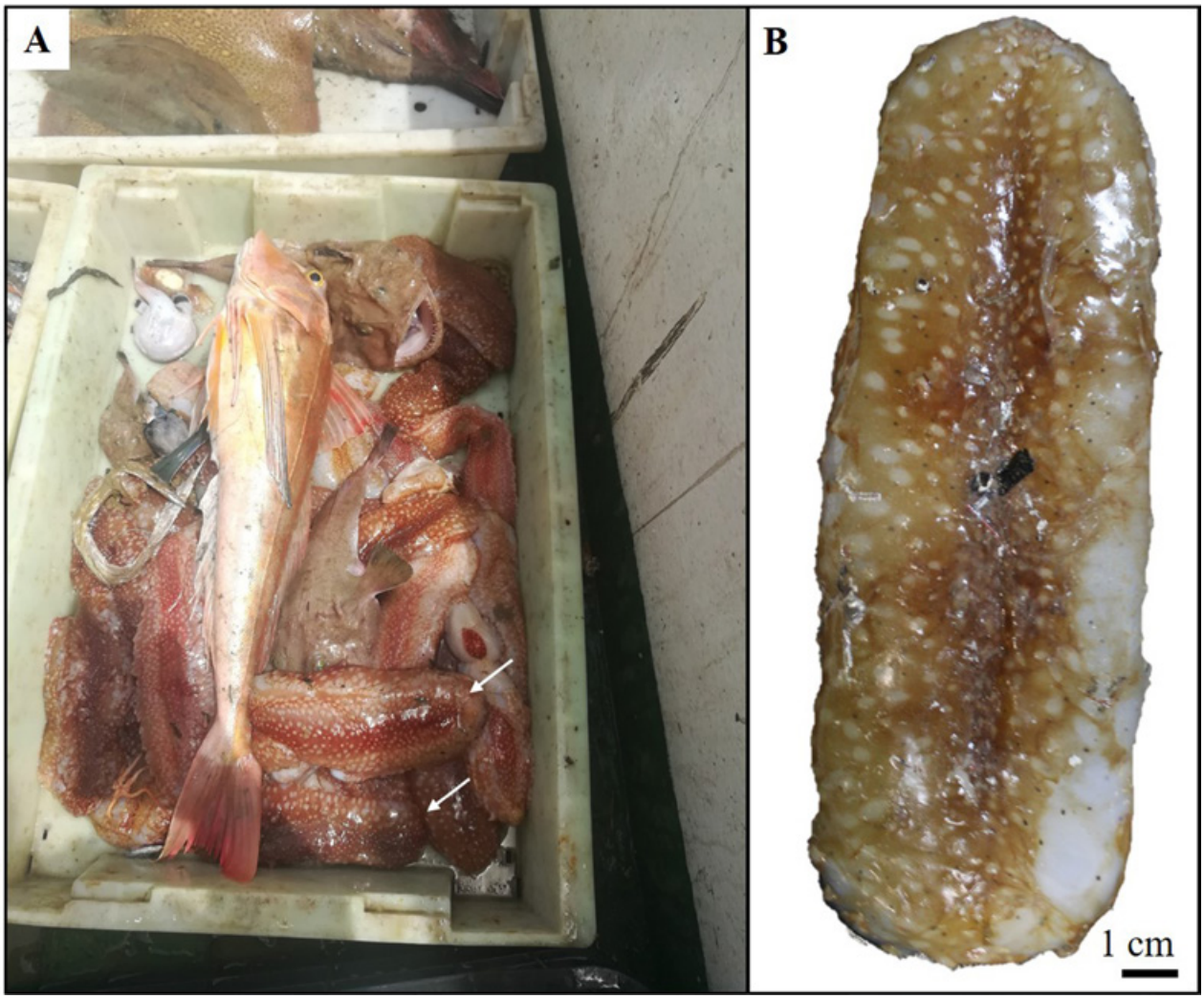

Figure 1. A. Trawler bycatch, including *Parastichopus regalis* (indicated by white arrows); B. dorsal side of *P. regalis*.

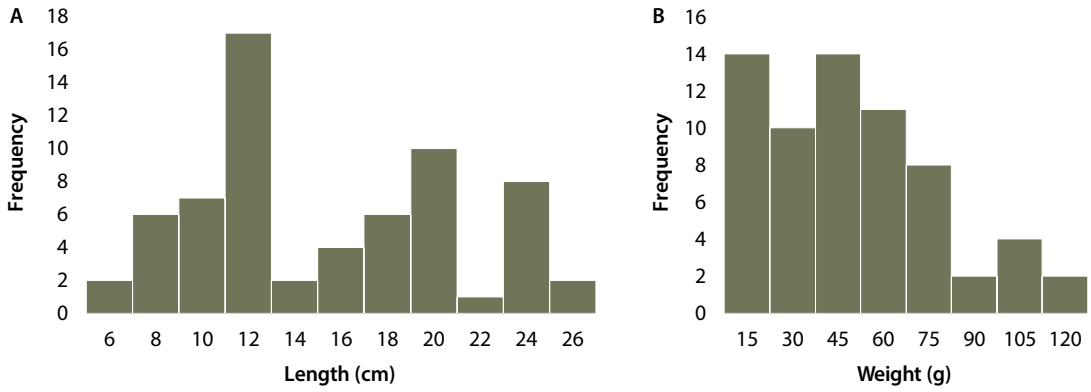

Figure 2. Length (A) and weight (B) frequency distribution of *Parastichopus regalis* from the Algerian west coast (n = 65).

Results and discussion

The individuals from the western Algerian coast (n = 65) have a mean length of 15.14 ± 5.51 cm, a mean width of 4.99 ± 1.22 cm, a mean weight of 61.55 ± 38.58 g, and a mean body wall thickness of 3.41 ± 1.55 mm. The length and weight frequency distributions of *P. regalis* are multimodal, with a major length modal class at 11–13 cm, and two major weight modal classes at 7.50–22.50 g and 37.50–52.50 g (Fig. 2A and 2B).

Table 2 summarises a comparison of the biometric measurements of *P. regalis* with other sea cucumber species of the same family. The mean length and weight values obtained in this study are lower than those obtained by Ramón et al. (2010) for the same species on the Spanish coast. This difference is probably due to the length measurement method used, which is the contracted length in the case of our study and the relaxed length in the case of the study of Ramón et al. (2010). Compared to some species of the Stichopodidae family from other regions (Mexico, Ecuador, Philippines), *P. regalis* from the Algerian west coast has the lowest value of mean length (Poot-Salazar et al. 2014; Dolorosa 2015; Pañola-Madrigal et al. 2017; Jesús-Navarrete et al. 2018; Ramírez-González et al. 2020).

These *P. regalis* length and weight values are also lower than those obtained for some other species of the genus *Holothuria* from Algeria's central and western coast (Mezali 1998; Mecheta and Mezali 2019).

Variation of the length and weight according to depth

A comparison of length and weight as a function of depth was performed using the Kruskal-Wallis non-parametric test. The results indicated that there was a significant difference, depending on depth whether for length (Kruskal-Wallis test = 32.654, $p < 0.05$) or for weight (Kruskal-Wallis test = 24.945, $p < 0.05$), between at least two depths. To determine the source of the differences, the Dunn post hoc test was applied, and the results are presented on the box plots by letters (Fig. 3). Different letters represent a significant difference ($p < 0.05$), while equal letters mean that there is no significant difference.

The Dunn test results for length (Fig. 3A) indicate that the station with a depth of 73 m (Bahara Mostaganem) is different from that of 225 m (Kharrouba Mostaganem 3) and 96 m (Bouzedjar). The latter also differs from that of 117 m (Kharrouba Mostaganem 2). For weight (Fig. 3B), the station with a depth of 117 m (Kharrouba Mostaganem 2) differs from those of 96 m (Bouzedjar), 113 m (Ghazaouet) and 225 m (Kharrouba Mostaganem 3).

The significant differences observed between the Mostaganem, Bouzedjar and Ghazaouet stations are probably due to the differences in region, however, considering the same region, namely Mostaganem, significant differences are found between stations at 73 m and 225 m for length, and 117 m and 225 m for weight. Although there is a difference between shallow and deeper depths, data are not sufficient for the same region to make a conclusion regarding the pattern of distribution of *P. regalis* individuals and whether, like other sea cucumbers, this species exhibits segregation between adults and juveniles, in which juveniles use shallow marine habitats and larger individuals move to deeper habitats (Reichenbach 1999; Mercier et al. 2000).

Biometric relationships

The biometric relationship between length and width (Fig. 4A) has a slope much higher than 1 ($p < 0.05$), indicating a positive allometry. Thus, the length grows four times faster than the width. The regression equation between L and SLW (Fig. 4B) used to generate the estimated length from the measured lengths and widths is Le = 2.102, SLW – 3.057 ($R^2 = 0.97$, $p < 0.05$).

Table 2. Biometric measurements of *Parastichopus regalis* compared to other sea cucumber species.

Species	L (cm)	l (cm)	T (mm)	W (g)	Region	References
Parastichopus regalis	15.14 ± 5.51	4.99 ± 1.22	3.41 ± 1.55	61.55 ± 38.58	West Algeria	Present study
	19.30 ± 4.30			177.20 ± 73.20	Spain	Ramón et al. (2010)
Isostichopus badionotus	22.61 ± 0.43				Mexico	Jesús-Navarrete et al. (2018)
	25.30 ± 5.20				Mexico	Poot-Salazar et al. (2014)
Isostichopus fusus	21.40 ± 6.00			375.60 ± 249	Mexico	Pañola-Madrigal et al. (2017)
	20.30 ± 5.00				Ecuador	Ramírez-González et al. (2020)
Stichopus chloronotus	24.10				Philippines	Dolorosa (2015)
Thelenota ananas	53.20				Philippines	Dolorosa (2015)
Thelenota anax	60.00				Philippines	Dolorosa (2015)

L = Length, l = width, T = body wall thickness, W = weight

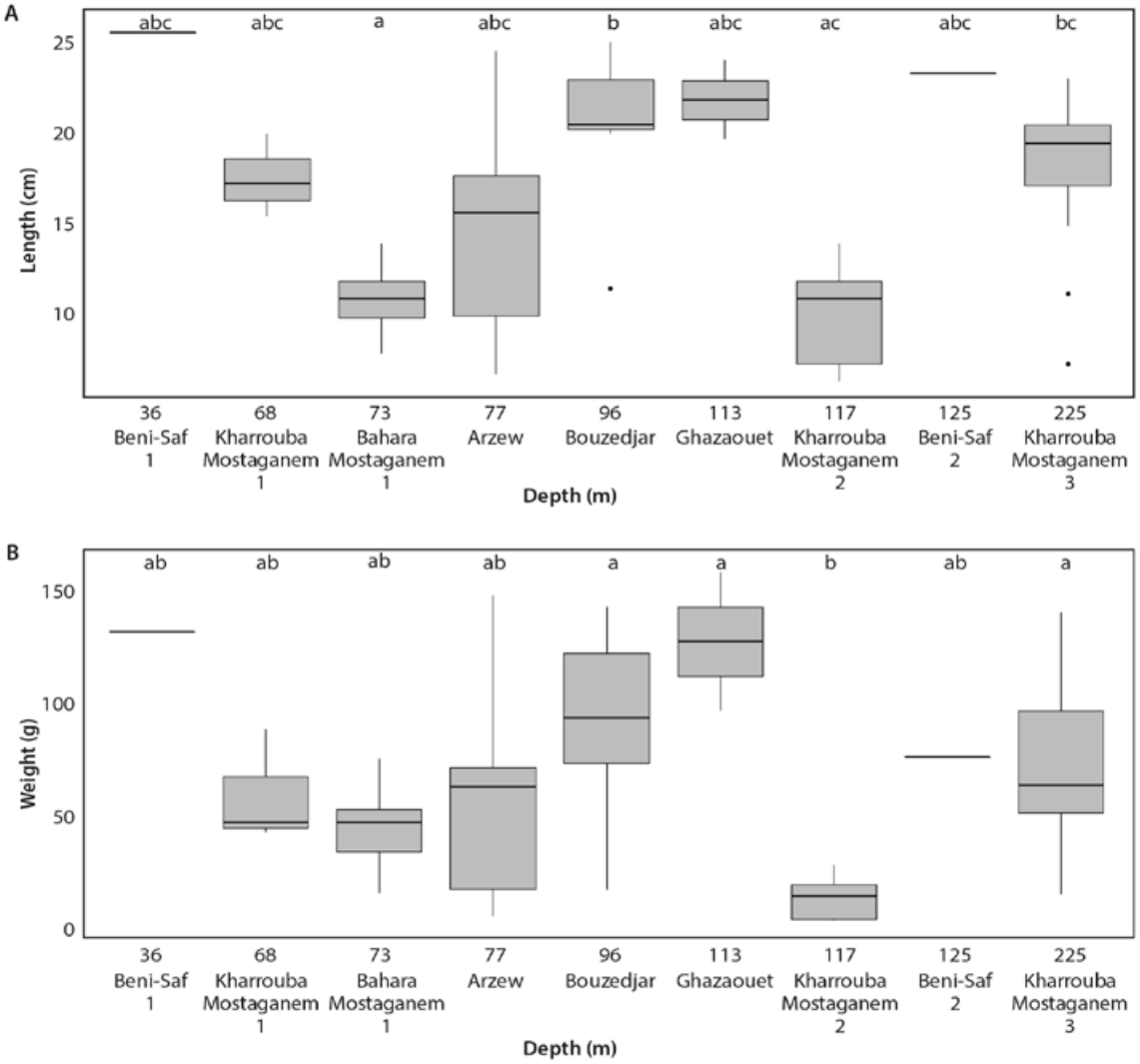

Figure 3. Box plots of length (A) and weight (B) of *Parastichopus regalis* categorised according to depth.

Length-weight relationships

The obtained "b" values are 1.784 and 1.836 for the length-weight relationship (Fig. 4C) and the estimated length-weight relationship (Fig. 4D), respectively. In both cases, the relationships are significantly different from 3 ($p < 0.05$), indicating a negative allometry, which means that the body length of the species grows faster than its weight. Using the estimated length derived from two measurements (length and width) rather than the measured length alone, improved the correlation coefficient and increased the regression coefficient "b", although the latter remains less than 3, indicating a negative allometry. These results are close to the results obtained for the same species on the Spanish coast (Ramón et al. 2010). Negative allometry is commonly observed in sea cucumber species of the same family as *P. regalis* or belonging to other families (Aydın 2020; Mezali 1998, 2001) in different regions of the world (Table 3), indicating that these species preferentially invest their resources in increasing their length rather than their body wall thickness (Pasquini et al. 2022).

Conclusion

Currently, *Parastichopus regalis* is nearly unexploited in Algeria. However, fishermen do not know the identity of the species when it is caught as bycatch, and often ask us questions in order to exploit it. We think that it will be the case in the future, especially given the signs of overexploitation being seen in other shallow-water sea cucumber species (genus *Holothuria*) in some areas. Although the exploitation of *P. regalis* remains nutritionally and economically beneficial, local authorities must initiate management programmes before launch an actual fishery in order to avoid destruction of the stock. On the other hand, it is important to beginwork on artificial reproduction in order to promote the farming sector of sea cucumbers with high aquaculture potential in integrated multitrophic aquaculture systems, with a view to rational industrialisation and marketing abroad.

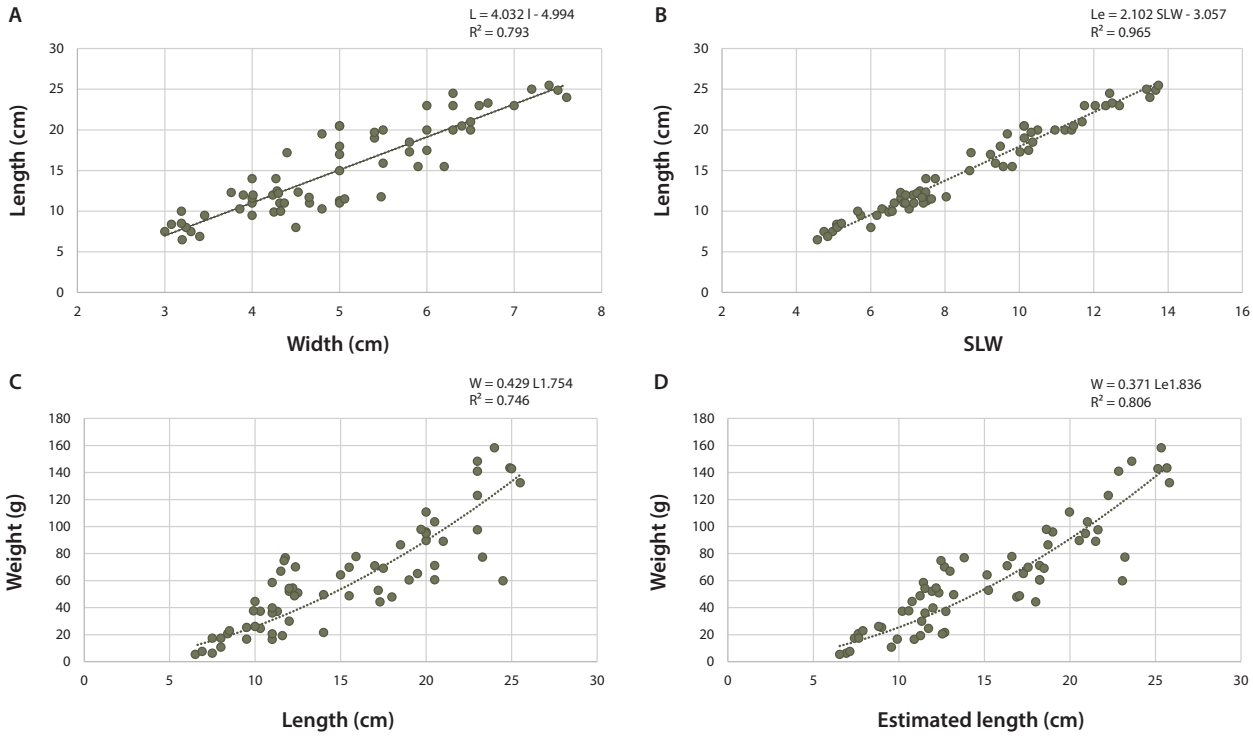

Figure 4. A. Biometric length-width relationship. B. Biometric length-SLW relationship. C. Length-weight relationship. D. Estimated length-weight relationship.

Table 3. Comparison of length-weight relationship parameters of sea cucumbers from different geographical regions.

Species	Model	a	b	R^2	Region	Reference
Parastichopus regalis	$W=aL^b$	0.429	1.784	0.746	West Algeria	Present study
	$W=aLe^b$	0.371	1.836	0.806	West Algeria	Present study
	$We=aL^b$	0.002440	2.112	0.83	Spain	Ramón et al. (2010)
Stichopus naso	$W=aL^b$	0.012	1.021	0.575	Sri Lanka	Veronika et al. (2018)
Thelenota ananas	$W=aL^b$	0.2247	2.1784	0.888	Seychelles	Aumeeruddy and Conand (2008)
Isostichopus fucus	$W=aL^b$	1.1421	1.8321	0.7141	Mexico	Herrero-Pérezrul and Reyes-Bonilla (2008)
Isostichopus badionotus	$W=aL^b$	2.8112	1.7411	0.7228	Mexico	Jesús-Navarrete et al. (2018)

L = length, Le = estimated length, W = weight, We = eviscerated weight

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