# A biometric study to determine the economic and nutritional value of sea cucumbers (Holothuroidea: Echinodermata) collected from Algeria's shallow water areas

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## Abstract

Traditionally in Algeria, sea cucumbers were exploited at a very small scale. Nowadays, however, sea cucumber fisheries are emerging in the Mediterranean Sea due to the high commercial value of these organisms. Three economically important species – *Holothuria (Roweothuria) poli*, *H. (Holothuria) tubulosa* and *H. (Roweothuria) arguinensis* – are common in shallow water areas along Algeria's coast. In order to enhance and highlight the economic and nutritional value of these unexploited holothurian species, a biometric study estimating the amount of water and pepsin digestion of the dry body wall, was undertaken. The three holothurians species were collected at two stations: Stidia and Hadjadj near the port city of Mostaganem. After their transformation into dried products, called beche-de-mer, we noticed a considerable decrease in their length (50–73%) and weight (88–93%). The dried body wall analysis showed a high moisture rate (over 80%) and pepsin digestibility (varying between 25% and 52%). We compared our results with those obtained for other holothurian species commonly exploited in the Indo-Pacific region.

Keywords: holothurians, biometrics, dried product, digestibility, Algerian west coast

## Introduction

The demand for beche-de-mer by consumer countries is constantly rising, resulting in increasingly intensive fisheries and a considerable decrease, and in some areas disappearance, of natural populations (Samyn et al. 2006). For that reason, Asian markets are in search of new target species, mainly from the Mediterranean Sea and the northeast Atlantic Ocean (Gonzalez-Wangüemert et al. 2015, 2016). In these regions, the most important species are *Holothuria (Roweothuria) poli* Delle Chiaje 1823, *Holothuria (Holothuria) tubulosa* Gmelin 1791, *Holothuria (Platyperona) sanctori* Delle Chiaje 1823, *Holothuria (Panningothuria) forskali* Delle Chiaje 1823 and *Parastichopus regalis* Cuvier, 1817.

Recently, *Holothuria (Roweothuria) arguinensis* Koehler and Vaney 1906, an invasive species originating from the Atlantic Ocean, has been reported in the Mediterranean (González-Wangüemert and Borrero-Pérez 2012; Mezali and Thandar 2014). In Algeria, holothurians are exploited on a very small scale (mainly as fishing bait) and no attempt has been made to process these species into dried product. In order to enhance and highlight the economic and the nutritional value of these unexploited holothurian species, a biometric study estimating the amount of water and pepsin digestion of the dried body wall was conducted.

## Methodology

Sampling was carried out during the summer of 2018. Three batches of 30 individuals of each species – *H. poli*, *H. tubulosa* and *H. arguinensis* – were harvested from two sampling sites on the Algerian west coast: Stidia (35° 50′N, 0° 00′E) and Hadjadj (36° 06′N, 0° 20′E) (Fig. 1). Each individual from each species was isolated in a plastic bag for later analysis.

### *Biometry*

In the laboratory, each sea cucumber individual was cleaned and then measured. The contracted length was obtained according to the standardised method described by Mezali (1998) using a semi-cylindrical scale (± 0.5 mm). Each measured individual was kept straight, and then compressed by hand until the coelomic fluid was expelled. After that, the individuals were dissected by making an incision

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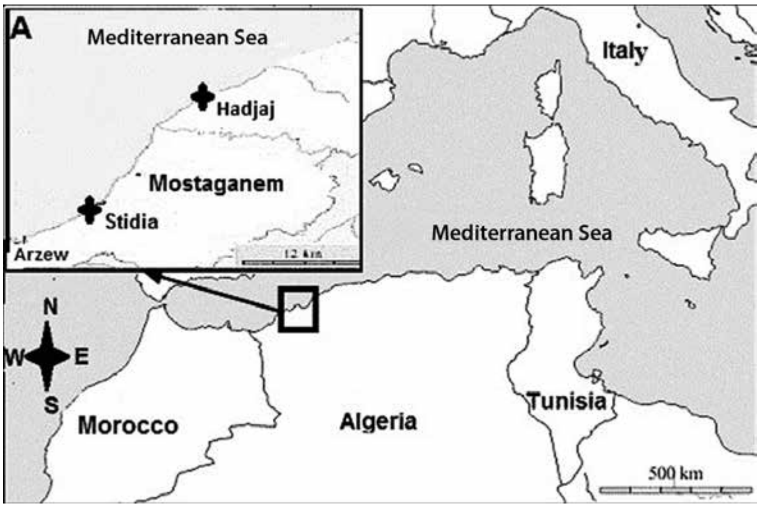


**Figure 1.** Detailed map of the two sampling sites (A) (black crosses).

of the trivium using a scalpel blade (Purcell 2014). Each individual was eviscerated, its gut and viscera removed, rinsed with tap water, drained and finally weighed: wet weight of the body wall (WW) (± 0.001g). The wet weight included the body wall, longitudinal muscle and the buccal bulb (Kazanidis et al. 2010; Mezali et al. 2014), and gave more accurate information than total body weight, which varies considerably, depending on the amount of water in the respiratory trees and the gut contents (mainly composed by exogenous materials) (Mezali 1998). The trivium thickness was measured using a caliper (± 0.1 mm). The moisture content of the body wall was measured according to the Official Methods of Analysis (AOAC 950.01 1990). The results have been expressed in percentages (%) (the mean of three replicates). The dried body wall of each individual was placed into a labelled plastic bag and stored in a freezer (-4 °C) for latter biochemical analysis. Fresh sea cucumbers were processed into dried products based on the simple, traditional methods described by Purcell (2014), and organised in three basic steps: cooking, salting and sun drying. Freshly collected holothurians were placed in a large container and boiled in sea water (60–80°C), and afterwards were placed in cold water (15°C for 1–2 h). An incision (with a scalpel blade) was made along the trivium, starting at 3 cm from each end, and the samples then gutted and rinsed in tap water. The specimens were kept in bins and entirely covered with salt for 2–5 days. Sea cucumbers were boiled again in sea water for ½ h, until a hard and chewy consistency was obtained. Finally, they were sun dried for 4–14 days.

## In vitro *digestion of the dried body wall with pepsin*

Dried body wall of *H. poli*, *H. tubulosa* and *H. arguinensis* were digested *in vitro* according to the method of Escudero et al. (2010) and amended by Wen et al. (2015). For this, 0.5 g of dried body wall of each species was weighed (± 0.001 g) (Jinghua JA3003, Shanghai, China) and then homogenised twice in 2 mL of distilled water for 30 s at 9,500 rpm $min^{-1}$ and then twice again for 30 s at 13,500 rpm $min^{-1}$ with a 30 s cooling time between the two centrifugations. The homogenates were adjusted to a pH of 2 with an acid (HCl 1M). Pepsin was added in a 1:31.25 ratio based on the body wall mass. The mixture was maintained at 37°C for 2 h, and then was made inactivate by adjusting the pH to 7.5 using a base (NaOH 1M). The undigested body wall was dried in an oven at 60°C for 72 h and then weighed. The *in vitro* digestibility was evaluated according to the following formula:

$$DT = (1 - Wi / Wt) \times 100\%$$

Where DT = digestibility (%);

Wi = dried weight of body wall after digestion;

Wt = total weight of the body wall of the dried product before digestion.

# Results and discussion

## *Biometry*

Our specimens demonstrated larger class sizes than those recorded by Mezali (1998) and Purcell et al. (2009) (Table 1). This difference could be due to several factors, such as a rapid growth due to a decrease in predation (Olaya-Restrepo et al. 2018). Although few predators feed on holothurians, several anti-predation mechanisms have been described in the literature for sea cucumbers (Francour 1997), and some of these mechanisms appear to be related to the animal's size. Moreover, this could also be linked to the high productivity of

*Posidonia oceanica* meadows, the preferred habitat for *H. poli* and *H. tubulosa* (Mezali 2004). In addition, the smaller the sediment particles, the higher the quantity of organic matter that can be ingested by holothurians, due to a higher volume-to-surface ratio that has previously been demonstrated to promote the adhesion of organic matter (Mezali and Soualili 2013). Moreover, Plotieau et al. (2013) suggested that the nutritional value of fine sediment would be higher than that for coarse sediments due to the greater number of nutritious microorganisms.

It is still, however, important to point out that estimating total body length is not a reliable measure. In fact, the error is likely to be higher than the actual weight because it is very difficult to obtain complete relaxation of holothurians' bodies; the length indeed changes significantly by contraction and elongation of their body (Battaglene et al. 1999). Therefore, weight measurements are more reliable (Mezali 1998). Based on this assertion, the average eviscerated weight was measured for the three species, and the maximum values were recorded as: *H. tubulosa* (112.64 ± 45.57 g), *H. arguinensis* (244.8 ± 61.26 g) and *H. poli* (90.22 ± 16.07 g) (Table.1). The relationship between length and weight differ between species, depending on the shape and strength of the body (Cone 1989). This is also due to food availability, species biology, growth rates and fishing pressure (González-Wangüemert et al. 2018).

A difference in body wall thickness could be observed between the three studied species: (5.99 ± 0.8 mm) in *H. tubulosa*, (3.44 ± 0.56 mm) in *H. poli* and (4.53 ± 1.03 mm) in *H. arguinensis* (Table1). According to González-Wangüemert et al. (2018), food is used differently by the two species – *H. poli* and *H. tubulosa* – with *H. poli* increasing in length while *H. tubulosa* increasing its body wall robustness (thickness of the body wall) and weight. Our results are not in agreement with this hypothesis because *H. tubulosa* presents the largest size classes, and a weight and body wall thickness greater than those recorded for *H. poli*, despite its more rigid body wall. Regarding *H. arguinensis*, although its specific growth model has already been determined by Olaya-Restrepo et al. (2018), there is no information on the relationship

**Table 1.** Biometric measurements obtained for the three studied holothurians species compared with other species of the Mediterranean and Indo-Pacific regions (n = sample size = 30). CL = contracted length (mm); T = thickness of the body wall (mm); WW = wet weight of the body wall (g); DW = dry weight of the body wall (g); and DL = dry length of the body wall (mm).

| Species | CL (mm) | T (mm) | WW (g) | DW (g) | DL (mm) | WW/DW | References |
|---|---|---|---|---|---|---|---|
| *Actinopyga echinites* | 190.00 ± 3.00 | - | 231.00 ± 14.00 | 35.00 ± 2.00 | 80.00 ± 2.00 | - | Purcell et al. (2009)b |
| *A. palauensis* | 270.00 ± 7.00 | - | 985.00 ± 44.00 | 165.00 ± 11.00 | 150.00 ± 5.00 | - | Purcell et al. (2009)b |
| *A. spinea* | 270.00 ± 10.00 | - | 735.00 ± 39.00 | 99.00 ± 11.00 | 130.00 ± 10.00 | - | Purcell et al. (2009)b |
| *Holothuria arguinensis* | 261.00 ± 55.16 | 4.53 ± 1.03 | 244.80 ± 61.26 | 15.51 ± 3.60 | 67.30 ± 5.22 | 15.78 | this study |
| *H. forskali* | 108.04 ± 28.90 | - | - | - | | 8.89 | Mezali (1998) |
| *H. lessoni* | 310.00 ± 10.00 | - | 1456.00 ± 50.00 | 221.00 ± 7.00 | 280.00 ± 10.00 | - | Purcell et al. (2009)b |
| *H. poli* | 144.03 ± 23.07 | 3.44 ± 0.56 | 90.22 ± 16.07 | 4 12.85 ± .59 | 71.60 ± 8.68 | 7.02 | this study |
| *H. poli* | 91.03± 43.10 | - | - | - | - | 6.44 | Mezali (1998) |
| *H. sanctori* | 115.60 ± 27.90 | - | - | - | - | | Mezali (1998) |
| *H. sanctori* | 225 ± 38.90 | 02.69 ± 1.95 | 76.90 ± 18.37 | - | - | - | Mezali et al. (2014)a |
| *H. tubulosa* | 187.30 ± 39.79 | 5.96 ± 1.26 | 112.64 ± 45.57 | 12.95 ± 1.32 | 74.20 ± 9.80 | 8.69 | this study |
| *H. tubulosa* | 120.15 ± 38.52 | - | - | - | - | 6.53 | Mezali (1998) |
| *H. whitmaei* | 250.00 ± 8.00 | - | 1174.00 ± 45.00 | 213.00 ± 14.00 | 150.00 ± 4.00 | - | Purcell et al. (2009)b |

[a] anesthetised total length
[b] length measurement criteria not indicated

between food availability and the strength of the body wall of this species. After being processed into beche-de-mer, the dried sea cucumbers were weighed and measured to estimate the weight and length loss. The results demonstrate a significant decrease in weight and size in all studied species (Table 1, Fig. 2). Lengths varied between 40.10% and 74.21%, and weights ranged from 85.72% to 93.65%. According to Conand (1990), after the drying process, the weight decreases between 90% and 97%, depending on the species. The salting phase allows dehydration of the sea cucumbers and removes part of the water contained in the body wall prior to sun drying. Similar studies conducted by Purcell et al. (2009) and Lavitra et al. (2009) on sea cucumber species exploited in New Caledonia and southwestern Madagascar, confirm our results as these authors have also found considerable decreases in the length and weight of fresh and dried sea cucumbers.

The ratio between wet weight and dry weight was calculated for all species. Considerable variations were observed between the three studied species (Table 1). The wet weight to dry weight ratio for both *H. poli* and *H. tubulosa* approximates the standard value 10:1 established for sea cucumbers by Newell and Courtney (*in* Astall and Johns 1991). But the ratio obtained for *H. arguinensis* is greater than the standard value 10:1. Our results also differ from those obtained by Mezali (1998) for similar species: *H. poli* (6.44:1) and *H. tubulosa* (6.53:1).

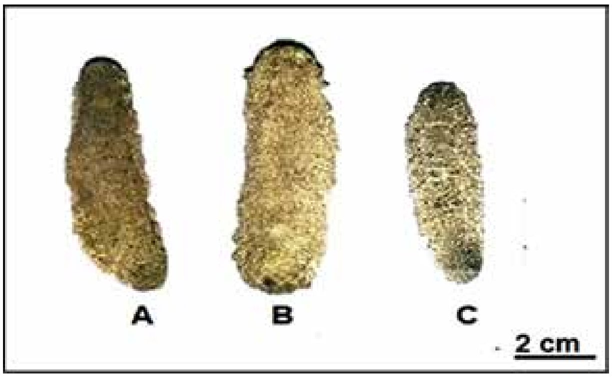


**Figure 2.** Dried sea cucumbers A. *H. poli*; B. *H. tubulosa*; C. *H. arguinensis* after processing into beche-de-mer, according to the traditional method. (image: Asmaa Mecheta)

**Table 2.** Water content (%) in the body wall of the three studied holothurians compared with Indo-Pacific species (no. replicates = 3).

| Species | Body wall water content (%) | References |
|---|---|---|
| *Actinopyga mauritiana* | 76.54 ± 0.09 | Haider et al. (2015) |
| *Holothuria arenicola* | 72.12 ± 0.25 | Haider et al. (2015) |
| *H. arguinensis* | 88.13 ± 4.16 | this study |
| *H. fuscogilva* | 84.34 ± 0.72 | Fawzya et al. (2015) |
| *H. leucospilota* | 81.41 ± 0.60 | Omran (2013) |
| *H. poli* | 93.53 ± 1.95 | this study |
| *H. poli* | 81.24 ± 0.40 | Aydin (2009) |
| *H. scabra* | 85.76 ± 0.30 | Omran (2013) |
| *H. tubulosa* | 81.99 ± 1.97 | this study |
| *H. tubulosa* | 84.30 ± 0.20 | Aydin (2009) |
| *Parastichopus californicus* | 04.03 ± 0.19 | Bechtel et al. (2013) |
| *Stichopus herrmanni* | 10.20 ± 0.32 | Wen et al. (2010) |
| *Thelenota ananas* | 90.81 ± 2.08 | Fawzya et al. (2015) |
| *T. anax* | 01.20 ± 0.06 | Wen et al. (2010) |

## *Water content and in vitro digestion of the* dry *integument*

Our results show very high moisture content for the three studied holothurian species (Table 2). Sea cucumbers generally have a higher moisture content than that of fish and seafood (Chang-Lee et al. 1989).

Table 3 shows the digestibility rate of the body wall of the three studied sea cucumbers by the digestive enzyme pepsin. The digestibility

**Table 3.** Digestibility (%) of the holothurian body wall when digested using pepsin.

| | Digestibility (%) | References |
|---|---|---|
| *Holothuria arguinensis* | 53.56 ± 3.41 | this study |
| *H. poli* | 34.68 ± 8.66 | this study |
| *H. tubulosa* | 25.96 ± 2.04 | this study |
| Pork | 47.22 | Wen and al. (2015) |
| Fish | 46.98 | Wen and al. (2015) |
| Chicken | 44.67 | Wen and al. (2015) |
| Beef | 42.75 | Wen and al. (2015) |

of *H. arguinensis* (53.56 ± 3.41%) was significantly higher than that of *H. poli* (34.68 ± 8.66%) and *H. tubulosa* (25.96 ± 2.04%) (Table 3). The digestibility level of *H. arguinensis* was more or less similar to that obtained by Wen et al. (2015) for commonly consumed meats (pork, fish, chicken and beef). This digestibility variation was attributed to the changes in protein bioavailability (depending on the protein decomposition rate when degraded by digestive enzymes), peptide size (Hur et al. 2011; Pennings et al. 2013), and protein and collagen contents that constitute the major components of the holothurians body wall (about 70% of the total body wall protein) (Saito et al. 2002; Wen et al. 2015). This latter factor may be significant due to the presence of glycosaminoglycans, which are widely distributed among the bundles of collagen fibers (Kariya et al. 1990).

## Conclusion

This biometric study of three aspidochirotid holothurian species – *H. poli*, *H. tubulosa* and *H. arguinensis* – before and after processing into beches-de-mer showed that our specimens are smaller in size and weight than those exploited in the Indo-Pacific region. A lower trophic factor combined with less organic matter content mostly explains these outcomes. Despite these two factors, the studied holothurians species showed significant nutritional value as their body wall is degraded by the digestive enzyme pepsin. Thus, they could become common sources of protein and other nutrients.

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