

Holothuria arguinensis: A new sea cucumber species for aquaculture

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Abstract

Sea cucumber fisheries have developed along the northeast Atlantic Ocean and Mediterranean Sea since the early 1990s, with an important incidence of illegal harvesting across these waters. Subsequently, in recent years, research has focused on aquaculture development. *Holothuria arguinensis* is a commercial sea cucumber species from the northeast Atlantic Ocean and Mediterranean Sea that has largely been studied for aquaculture. This work summarises the main findings on and advances in aquaculture involving *H. arguinensis*.

Introduction

Sea cucumbers are economically valuable and are in high demand from Asian markets because they are considered a delicacy and functional food,² and are also used in traditional Chinese medicine (Chen 2004; Conand 2000, 2004; Bordbar et al. 2011; Fabinyi 2012; To and Shea 2012). High market demand, uncontrolled exploitation and inadequate fisheries management, have all led to many sea cucumber stocks becoming heavily overfished, and have driven fishers to target lower-value species around world (Conand 2004). Nowadays, fishing pressure is also focused on species from the northeast Atlantic Ocean and Mediterranean Sea (Aydin 2008, 2017; González-Wangüemert et al. 2014, 2015, 2018; Maggi and González-Wangüemert 2015). Sea cucumber aquaculture began in China in the 1980s to: 1) supply beche-de-mer (dried sea cucumber) to the Asian market, 2) compensate for reduced wild stocks, and 3) allow restocking for enhancement of depleted populations (Chen 2004; Hu et al. 2010). Traditionally, sea cucumbers have been farmed in earthen ponds and in sea ranching systems, and have been grown in polyculture systems with other species (Hu et al. 2010). Sea cucumber aquaculture in Europe has great potential for development, which could include integrated, multi-trophic systems.

Holothuria arguinensis (Fig. 1) is restricted in distribution to the northeastern Atlantic, from Peniche,

Portugal, to Mauritania, and the Canary Islands (Costello et al. 2001; Rodrigues 2012; Rodrigues et al. 2015; Thandar 1988). It has recently been found colonising the waters of the Alborán Sea in the western portion of the Mediterranean Sea (González-Wangüemert and Borrero-Pérez 2012; Mezali and Thandar 2014). This species has been illegally harvested in Portugal and Spain, mainly due to the high prices it fetches: EUR 70–350 per kilo of dried product (beche-de-mer), depending on the quality (Domínguez-Godino and González-Wangüemert 2018a; González-Wangüemert et al. 2018). *Holothuria arguinensis* has a nutritional value similar to that of other commercial sea cucumber species and is suitable for human consumption (Roggatz et al. 2015). Therefore, *H. arguinensis* is a good candidate for aquaculture development. Since 2014, techniques needed for *H. arguinensis* aquaculture have been developed.

Holothuria arguinensis broodstock maintenance and larvae rearing

Holothuria arguinensis broodstock can be maintained in tank-based conditions with sediment, and their weight increased (SGR³ = 0.2 % day⁻¹) by feeding them the supplied sediment (mean feeding rate: 27.88 g ind.⁻¹ day⁻¹), which shows high values of absorption efficiency (80%) in terms of organic matter (Domínguez-Godino and González-Wangüemert 2018a). *Holothuria arguinensis* is highly influenced by seawater temperature and salinity,

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² See: <https://academic.oup.com/jn/article/132/12/3772/4712139>

³ SGR = special growth rate

⁴ AGR = absolute growth rate

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Figure 1. a) Juvenile specimen of *Holothuria arguinensis* (image: Pepe Brix). Specimens of *H. arguinensis* b) dorsal side, and c) ventral side with different colouration. (images: Jorge Antonio Domínguez Godino)

both of which can induce a hibernation period (Domínguez-Godino and González-Wangüemert 2018a). When the seawater temperature drops below 19°C, *H. arguinensis* reduces its feeding, movements, absorption efficiency and growth (Domínguez-Godino and González-Wangüemert 2018a). During broodstock maintenance, artificial feed from the debris of the seagrass *Zostera noltii* can be used to ensure growth (Fig. 2, SGR = 0.09 ± 0.06 % day⁻¹, AGR⁴ = 0.11 ± 0.07 g day⁻¹) (Domínguez-Godino 2018). However, biodebris from the seagrass *Cymodocea nodosa* seems to be an unsuitable food source for *H. arguinensis*, causing negative growth (Domínguez-Godino 2018). Independently of the seagrass species and the proportion used in the diets, any important change to the nutritional values of *H. arguinensis* was registered (Domínguez-Godino 2018).

Domínguez-Godino and colleagues were able to induce *Holothuria arguinensis* to spawn by thermal stimulation during the summer months, which correspond to its reproductive period of June–October. The authors followed and described the embryonic

and larval development thereafter (Domínguez-Godino et al., 2015). *Holothuria arguinensis*, as with most aspidochirote holothurians, exhibits the classic five larval stages (early, mid and late auricularia, doliolaria and pentactula), reaching the juvenile stage after 18 days (Domínguez-Godino et al. 2015). Low mortality was registered by Domínguez-Godino and colleagues (2015) during the pelagic larval stages, but high mortality (85–95%) was registered at the doliolaria and juvenile stages during the first year. Survival has since been improved, and juvenile production has increased (Domínguez-Godino et al. 2015). Feeding diets based on single-life microalgae (*Chaetoceros calcitrans*, *Isochrysis galbana* and *Tetraselmi chuii*) were compared with two combined microalgal diets: 1) *C. calcitrans* and *T. chuii* (C:T) (pre-established feeding diet), and 2) *C. calcitrans*, *T. chuii* and *I. galbana* (C:T:I) to improve the growth and survival of *H. arguinensis* (Domínguez-Godino 2018). Larvae fed with the combined microalgal diet of T:C:I showed higher survival rates and larger larval and stomach sizes than larvae fed with the single microalgal diet and the pre-established microalgal diet (C:I) (Domínguez-Godino 2018).

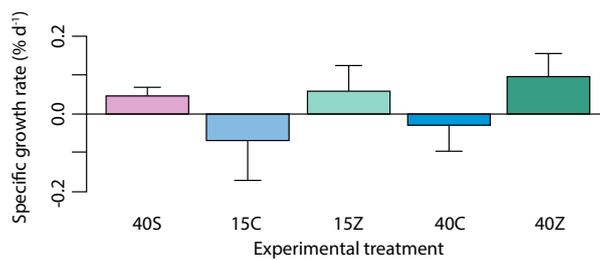


Figure 2. Specific growth rate (%/d) of *Holothuria arguinensis* individuals over eight weeks for each feeding treatment: sediment (40S), 15% of *Cymodocea nodosa* (15C), 15% of *Zostera noltii* (15Z), 40% of *C. nodosa* (40C), 40% of *Z. noltii* (40Z). Values are given as mean \pm SE (n = 3).

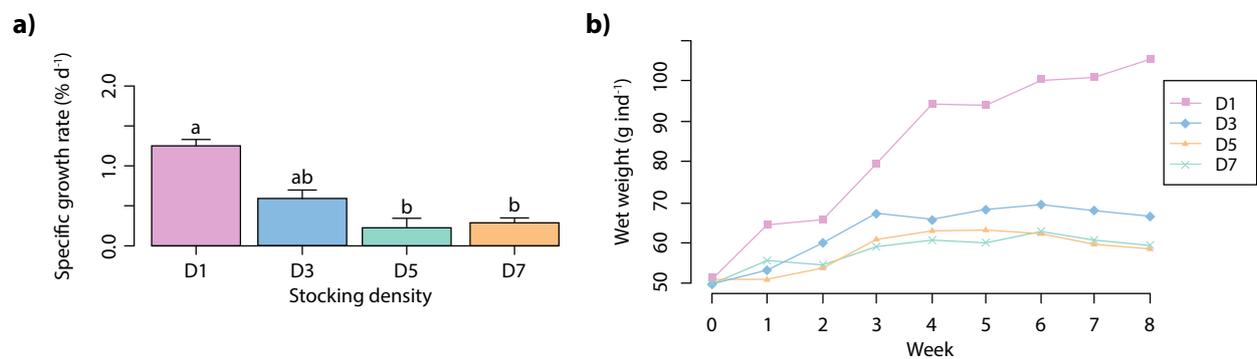


Figure 3. (a) Specific growth rate (%/d) of *Holothuria arguinensis* individuals over eight-weeks for each stocking density: 1 ind. 0.2 m² (D1), 3 ind. 0.2 m² (D3), 5 ind. 0.2 m² (D5), 7 ind. 0.2 m² (D7). (b) The mean wet weight of *H. arguinensis* (g) in the different stocking densities during the eight-weeks period. Values are given as a mean \pm SE (n = 3). Different letters indicate significant differences (Nemenyi post hoc, P<0.05).

Holothuria arguinensis stocking density and grow-out habitat selection

Stocking density is one of the main parameters affecting the growth, feeding and survival of the sea cucumber. Juvenile *H. arguinensis* showed the best growth (SGR = 1.25 \pm 0.08 % day⁻¹, AGR = 0.94 \pm 0.05 g d⁻¹ and %WC = 104.66 \pm 9.98 %) at a stocking density of 5 ind. m², decreasing significantly as the stocking density increased (Fig. 3a) (Domínguez-Godino and González-Wangüemert 2018b). Critical biomass (471.65 g m⁻²) was reached in four weeks (Fig. 3b) (Domínguez-Godino and González-Wangüemert 2018b).

Additionally, habitat preferences of *H. arguinensis* were assessed in the coastal lagoon at Ria Formosa Natural Park (south Portugal). There, *H. arguinensis* was preferentially distributed along the lower intertidal zone and linked to *Zostera noltii* meadows on muddy and sandy bottoms, where the densest population and largest individuals were found (Domínguez-Godino 2018). This habitat selection by *H. arguinensis* could be linked to the greater

amount of emersion time and exposure to high temperatures and ultra-violet rays of the upper intertidal zone (Domínguez-Godino 2018). Therefore, areas located in the lower intertidal zone with *Z. noltii* meadows on sand-muddy bottoms should be selected for sea pen grow-out of *H. arguinensis*.

Holothuria arguinensis in integrated multitrophic aquaculture

The monoculture growth, productivity and economic benefits of *H. arguinensis* were compared with three polyculture systems where the green macroalgae *Ulva lactuca* and purple sea urchin *Paracentrotus lividus* were included (Domínguez-Godino 2018). The highest growth, productivity and economic benefits for both cultured species occurred where *H. arguinensis* was co-cultured with *U. lactuca* and where artificial feed (dry powder of *U. lactuca*) had been added (Fig. 4) (Domínguez-Godino 2018). The three polyculture systems produced greater economic benefits than the monoculture systems; therefore, these systems could be implemented to improve productivity in terms of biomass and

profits (Domínguez-Godino 2018). Additionally, the feasibility of using biodeposits of the sea bream, *Sparus aurata*, as a food source for *H. arguinensis* was assessed (Domínguez-Godino and González-Wangüemert 2018a). *Holothuria arguinensis* showed a low feeding rate, negative absorption efficiency, and growth, but this could have been a consequence of the low seawater temperature during the experiment, which was performed in winter (Domínguez-Godino and González-Wangüemert 2018a). Previous similar experiments had shown high feeding rate and absorption efficiency (Domínguez-Godino and González-Wangüemert 2018a), so further research should be done during spring and summer months.

Conclusion

Different and important techniques to develop sea cucumber aquaculture have been studied in recent years. This study is the first one to focus on the northeastern Atlantic Ocean and Mediterranean Sea holothurian, *H. arguinensis*. This work has established the baseline for its aquaculture, and shows that *H. arguinensis* is a highly suitable sea cucumber species for one-species and integrated multi-trophic aquaculture. Further research is needed to confirm the results obtained and address issues that will arise when entering production stages.

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