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# Is there a difference between bêche-de-mer processed from ocean-cultured and wild-harvested sandfish (*Holothuria scabra*)?

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ABSTRACT

The dried body wall of sea cucumbers, known as bêche-de-mer (BDM), is a luxury food item, exported from most producing countries to S.E. Asian markets. Interest in sea cucumber mariculture has grown and the sandfish (*Holothuria scabra*) is the major mariculture prospect in the tropical Indo-Pacific. While speculation that pond-cultured sandfish may lose more weight during processing than wild ones has not been confirmed, this is an important issue potentially impacting the profitability of sandfish mariculture. This study presents a unique set of comparison data for similar-sized ocean-cultured (hatchery bred) and wild-harvested sandfish from New Ireland Province, Papua New Guinea (PNG), that were processed concurrently using the same methods. The following results were obtained for the two groups: recovery rate from fresh whole weight to dried weight was significantly different (5.0 ± 0.2 vs 5.6 ± 0.2%, for ocean-cultured and wild-harvested sandfish, respectively; $P = 0.047$); recovery rate from fresh gutted weight to dried weight was not significantly different (8.8 ± 0.2 vs 9.6 ± 0.3%, $P = 0.055$); ratio of dried to fresh length was not significantly different (52.3 ± 1.2 vs 49.7 ± 1.0%, $P = 0.099$); thickness of the fresh body wall was significantly different (5.6 ± 0.3 vs 6.6 ± 0.3 mm; $P = 0.033$); thickness of the dried body wall was not significantly different (2.7 ± 0.1 vs 2.9 ± 0.1 mm, $P = 0.23$); collagen content of the dried body wall was not significantly different (94.5 ± 6.4 vs 104.0 ± 9.7 mg $g^{-1}$, $P = 0.422$); and ash content of the dried body wall was not significantly different (15.2 ± 1.1 vs 14.0 ± 1.2%, $P = 0.404$). Although differences between wild and cultured sandfish were found, several key determinants of BDM quality (i.e. recovery rate from fresh gutted weight, dried length ratio, dry body wall thickness and collagen content) were not significantly different between the two groups. Overall, this is reassuring information for sandfish mariculture proponents and augers well for the future of sea ranching in PNG and other areas where this species is cultured.

*Statement of relevance:* Increased confidence in the quality of bêche-de-mer from cultured sandfish (*Holothuria scabra*).

## 1. Introduction

Sea cucumbers support important fisheries in the tropical Pacific where they are processed into a dried product called bêche-de-mer or trepang. Bêche-de-mer (BDM) is a very valuable product in Chinese and other Asian markets, where it is regarded as a culinary delicacy with many health benefits (Conand, 1990; Yang and Bai, 2015). BDM is the dry body wall of sea cucumbers and its quality is determined by various factors including the species used, size and processing method (Skewes et al., 2004; Brown et al., 2010; Purcell, 2014a). Sandfish (*Holothuria scabra*) is the highest value tropical sea cucumber species (Purcell, 2014a). It has a circum-tropical Indo-Pacific distribution but has been overexploited throughout most of its range (Hamel et al., 2001; Purcell et al., 2012a). However, sandfish is amenable to culture and is the focus of mariculture research in a growing number of countries including India, Maldives, Philippines, Vietnam, Saudi Arabia, Madagascar and a number of Pacific island countries (Lovatelli et al., 2004; Hair et al., 2012; Purcell et al., 2012b).

Processing BDM is relatively easy, uses low technology methods, and the dry product is non-perishable, making it ideal for rural and remote coastal communities (Conand, 1990). To produce BDM, the fresh sea cucumber is gutted, boiled at least once, and dried in the sun

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or over a fire (Preston, 1993; Anon, 1994; Purcell, 2014b). The method has changed little in the Pacific since it was introduced in the 1800s (Ram et al., 2014), although salting is an increasingly popular step in BDM processing (Lavitra et al., 2008; Purcell, 2014b), and some commercial processors use oven-drying to reduce drying time and facilitate product uniformity. The method used and care taken during processing are important because both can affect the quality of resulting BDM and the recovery rate, i.e. the amount of BDM recovered from the initial fresh weight of live sea cucumber (Skewes et al., 2004; Ram et al., 2014). Traditionally, sandfish require an additional processing step in order to remove the calcareous ossicles in their outer skin layer. The skin is usually softened after the first boiling, either by overnight soaking in seawater, burying in sand, or treating with papaya leaf extract, and then the chalky layer is removed by brushing or scraping (Preston, 1993; Purcell, 2014b). Removal of the ossicles is necessary to produce high-grade sandfish BDM (Purcell, 2014a). Despite recent trends towards marketing of more contemporary products, most sea cucumbers from the Western Pacific region are still processed as BDM for export (Kinch et al., 2008; Purcell et al., 2014; Barclay et al., 2016).

Claims that pond-cultured sandfish lose twice the amount of weight during processing than wild conspecifics (Agudo, 2012), and speculation that their body wall may be thinner (Purcell and Duy, 2012), have not yet been tested, and no information on potential differences between ocean- (pen-) cultured sandfish and wild-harvested sandfish is currently available. However, if such differences are apparent, they could compromise the economic viability of sandfish mariculture. The above assertions refer to pond-cultured sandfish and do not elaborate on whether such differences might result from the use of hatchery progeny or grow-out conditions or some other factor. However, perceived inferiority of cultured sandfish could negatively impact future prospects and profitability of sandfish mariculture. Additionally, if cultured sandfish require longer culture periods to achieve comparable recovery rates to wild-harvested individuals, then profitability will be reduced. The cropping cycle (i.e. grow-out duration to commercial size) is especially crucial in sandfish mariculture because larger sandfish BDM has greater value. Purcell (2014a) reported that the price of sandfish BDM increased from around US$100 $kg^{-1}$ for 5–6 cm long individuals to four times that value for > 11 cm long individuals. Body wall thickness is also a key determinant of commercial value of BDM (Skewes et al., 2004) with thicker body wall flesh associated with improved texture and eating quality (Lo, 2004). The body wall of sea cucumbers contains a high proportion of collagen (Xia and Wang, 2015), which influences BDM firmness and texture (Saito et al., 2002; Ram et al., 2017). Thus, a thinner body wall may indicate reduced collagen content, which could infer reduced quality and lower value product.

With ongoing improvements in sandfish mariculture (Raison, 2008; Purcell et al., 2012b; Robinson, 2013) and a growing interest in sea ranching of this species, it is of critical importance to investigate potential quality discrepancies. There are no published records for recovery rates of cultured and wild sandfish processed concurrently using the same method. This report provides size, recovery rates and compositional information for ocean-cultured sandfish and wild-harvested sandfish from New Ireland Province, Papua New Guinea (PNG). They were processed to obtain directly comparable data and thus address the question of whether BDM processed from ocean-cultured sandfish is any different to that processed from wild sandfish.

## 2. Materials and methods

### 2.1. Sample collection

Adult cultured sandfish were collected from a sea pen at Limanak, a village grow-out site for community-based sea cucumber mariculture research in Kavieng, PNG (Hair et al., 2016). These sandfish were hatchery produced, reared for 1 month at the Nago Island Mariculture and Research Facility (NIMRF), on-grown in ocean bag nets for 2 months, and then stocked into the sea pen at an average weight of around 5 g. They were grown in the pen for 15 months before collection, at 18-months old, for this study. Fifty individuals, representing the full size range of sandfish in the pen, were removed from the water and allowed to drain for several minutes before fresh whole weight (referred to as whole weight) was recorded to the nearest 1 g. The sandfish were transferred to a raceway (without substrate) at NIMRF, and provided with aeration and flow-through unfiltered seawater until processing. At collection, the individual whole weights of the cultured sandfish ranged from 174 to 594 g, with a mean ( ± SD) weight of 423.8 ( ± 103.4) g.

Adult wild sandfish were collected from a shallow sand-seagrass habitat approximately 2 km from the sea pen location to avoid the possibility of collecting cultured escapees closer to the trial sea pens. Modelling has indicated that sandfish are unlikely to move outside a 1-ha area in the first 2 years after release (Purcell and Kirby, 2006). This is supported by our data from these study sites in PNG which show that the maximum distance covered by sandfish 6 months after release is 100 m. Furthermore, recruitment of the progeny of cultured sea cucumbers into the 'wild' population sampled, and their growth to the size sampled, was not possible within the timeline of culture activities at these sites. Fifty wild individuals were collected and measured in the same way as cultured individuals. To reduce the influence of size difference, which may affect the recovery rate (Skewes et al., 2004), we collected wild sandfish of similar whole weight (i.e. ± 10 g) of the sampled cultured sandfish. The wild-harvested sandfish were transported to NIMRF and transferred into a second identical raceway (isolated from the cultured sandfish) until processing. At collection, the individual whole weights of the wild sandfish ranged from 180 to 590 g, with a mean ( ± SD) weight of 424.5 ( ± 103.3) g.

### 2.2. Processing and data collection

Processing began approximately 20 h after collection of the cultured sandfish and 3 h after collection of the wild sandfish. Initial treatment and handling was identical for all sandfish. Individuals were removed from their holding tank, allowed to drain for 2 min, then fresh whole weight and length were recorded to the nearest 1-g and 1-mm, respectively. After evisceration to remove the internal organs and coelomic fluid, a 7–8 cm slit was made in the dorsal surface and the body cavity cleaned of viscera. Note that bêche-de-mer processing for this species would normally entail a small cut on the underside of the animal (Anon, 1994; Purcell, 2014b); however, the larger dorsal incision facilitated measurement of each side of the fresh body wall to the nearest 0.1 mm with dial callipers. Fresh gutted weight (referred to as gutted weight) was recorded and then each sandfish was labelled with a numbered plastic tag on a coloured cable tie threaded through the body cavity and anus. Tag number and cable tie colour combinations were unique for each sandfish to enable identification of individuals through all subsequent processing steps. However, when processing began it became apparent that gutted weights of the cultured and wild groups varied more than whole weights at collection. Skewes et al. (2004) found that gutted weight was a more reliable estimate of true body weight. We therefore selected paired individuals of similar gutted weight from the sandfish available for the experiment. Thus, 23 pairs of sandfish consisting of a wild and cultured individual were selected to be approximately matched in weight, so that starting condition of each group was similar (cultured 230.9 ± 53.3 g, wild 232.5 ± 63.3 g; mean ± SD). This subset of 46 sandfish was then processed to a fully dry state using a modified basic BDM processing method, similar to those used in PNG and the Pacific (Anon, 1994; Ram et al., 2016). Sandfish were cooked in a large pot of 50 °C seawater and the water heated further while stirring for 15 min (this is referred to as the first 'boil', even though the water does not reach boiling point). Boiled sandfish were held in a bag in running seawater for 12 h, then brushed