Sandfish Biology and Ecology: Prospects and Challenges for IMTA in the Tropics

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Introduction

Sea cucumbers are highly valued in China and Southeast Asian markets for food and nutraceutical uses (**Figure 1**). This has caused overfishing in many parts of the tropics, and combined with poor fisheries management, has resulted in severe declines in wild stocks (Anderson *et al*. 2011; Purcell *et al*. 2013). As such, interest in the aquaculture of these commercially-valuable echinoderms has spread throughout the world (Bell *et al*. 2008; Juinio-Meñez *et al*. 2017; Purcell *et al*. 2012; Purcell and Wu 2017).

Figure 1. Expensive dried sea cucumbers for sale in a Chinese market

The sandfish *Holothuria scabra* is among those with the highest potential for aquaculture because the technology for production in hatcheries has been established (Agudo 2012; Battaglene 1999; James *et al.* 1994; Pitt and Duy 2003). In terms of value, dried sandfish commands over US$1,500 per kilo in Chinese markets, coming in as a close second to the most valued sea cucumber, the Japanese spiky sea cucumber *Apostichopus japonicus*, with prices reaching over US$ 2,000 per kilo in its dried form (Purcell *et al.* 2014) (**Figure 2**). Since the latter is a temperate species, it leaves the sandfish *H. scabra* as the most suited choice for tropical aquaculture.

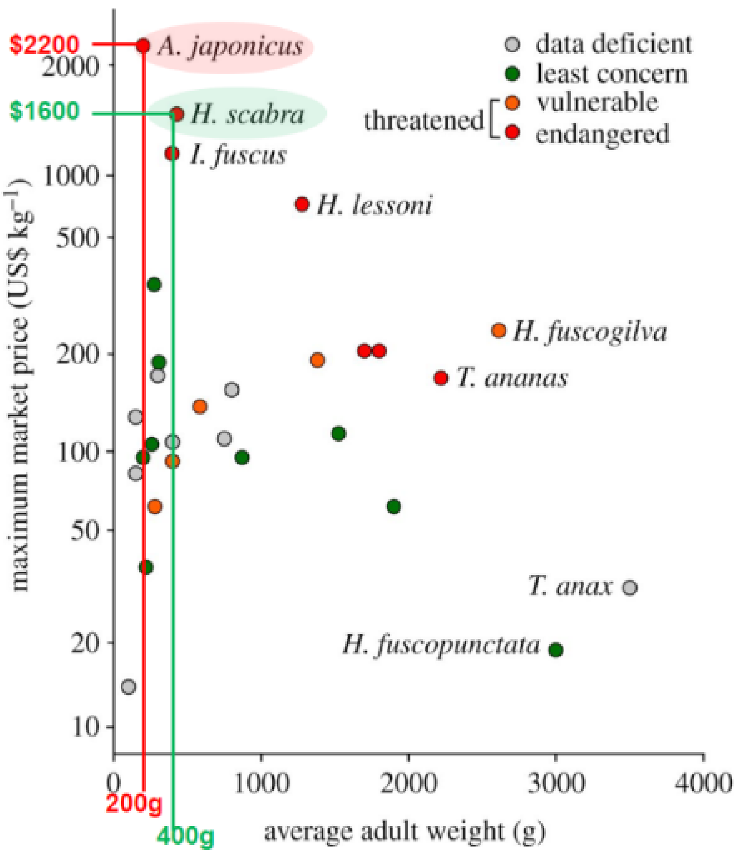

Figure 2. Species of sea cucumbers and their prices (US$) at given weight (fresh wet weight in g), highlighting *A. japonicus* and *H. scabra* (Adapted from: Purcell *et al.* 2014).

Biology and ecology of sandfish relevant to aquaculture

Sandfish are echinoderms that belong to the Order Aspidochirotida with oral tentacles to feed on the rich biofilm that coats most sandy intertidal shores. Their diet involves microalgae, small animals, bacteria, and organic matter that may be present on the substrate's surface. This aspect of omnivorisity is an advantage to the aquaculture potential of this species, where they can be grown even without supplemental feeds. Non-feeding culture systems are the general practice in existing sandfish aquaculture ventures and sea ranching.

Sandfish generally feed on natural biofilm on the sediment surface during the night which peaks at 15:00–03:00 h, and are mostly buried during the day (03:00–09:00 h) (Altamirano *et al.* 2017; **Figure 3**).

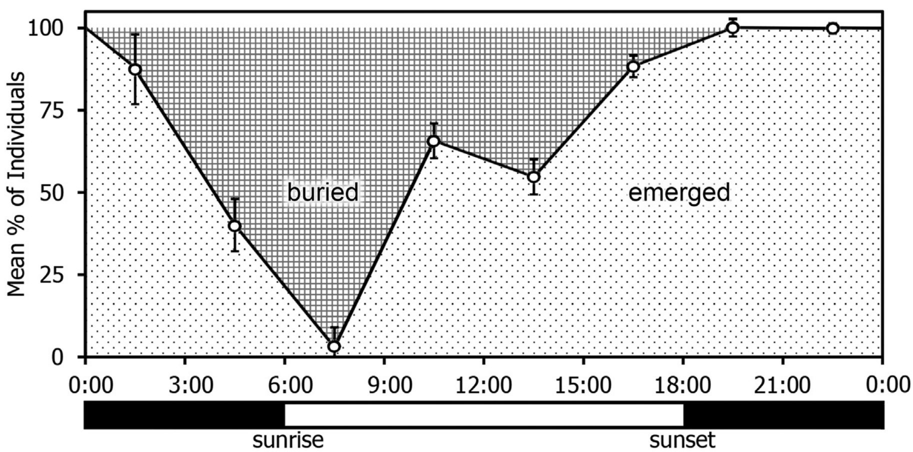

Figure 3. Daily feeding and burying schedule of sandfish (Source: Altamirano *et al.* 2017)

Altamirano *et al*. (2017) reported that, especially for sandfish juveniles, sandy mud substrate is preferred for both burying and feeding, and that substrate preference was not influenced by the presence of seagrass. It is also important to note that silty-mud sediments associated with muddy mangrove areas, culture ponds, and aquaculture areas seemed to be not an ideal substrate for sandfish culture (**Figure 4**). Basically, sandfish are sediment-dwelling animals and therefore require loose sandy substrate to feed on, and bury in. So, culture systems for this species will need to consider the required sediments like in ponds, or sea ranch in natural intertidal areas.

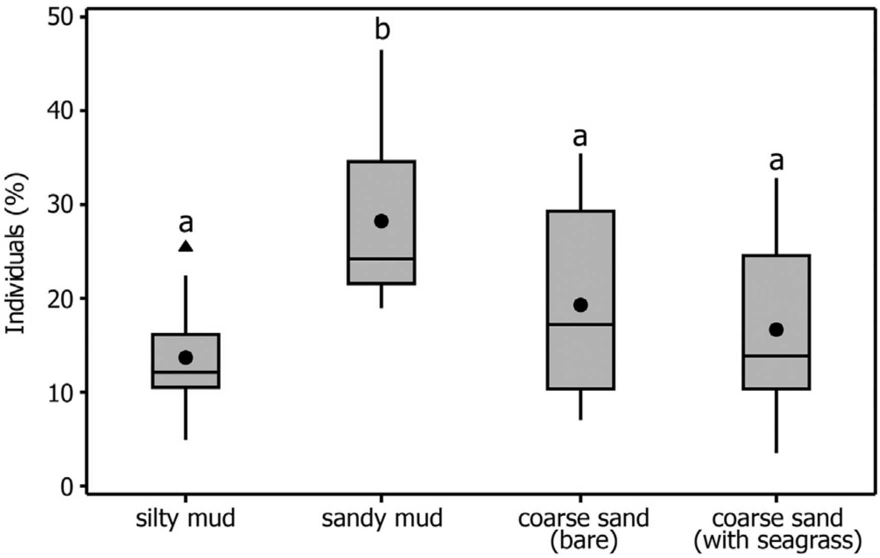

Figure 4. Sandfish substrate preference for burying (Source: Altamirano *et al.* 2017)

Like all other echinoderms, sandfish is purely marine. They can tolerate only as low as 20 ppt of salinity but should ideally be grown in around 30–35 ppt of clean seawater. Preliminary studies show that confinement of sandfish in tanks for longer periods (*e.g.* >2 months) will render them unproductive, where they tend to lose weight and shrink. Wider tanks and lower stocking densities can mitigate this shrinkage but not indefinitely. It is therefore recommended that culture areas will need to be wide (*e.g.* hectares) in order to promote better growth and survival of sandfish.

Aquaculture options for sandfish

Sandfish is an emerging species for aquaculture. There are currently a number of factors favoring the culture of this species. These include the well-established market acceptance in Asia, very high market value, declining wild stocks, availability of suitable species, low disease risks, availability of commercial technology, and a range of culture system options (Azari *et al.* 2010). Because of the development of hatchery technology for sandfish, the needed seedstocks for aquaculture are already available in some countries. Grow-out culture is being done in small-scale earthen ponds in Viet Nam, intertidal pens in Madagascar, open sea ranch in the Philippines, wide large-scale pond polyculture in China, and even in in-land tanks in Saudi Arabia (**Figure 5**).

Figure 5. Some grow-out culture systems for sandfish.

Prospects & challenges of sandfish in IMTA

In a traditional IMTA system, the major species (typically fish) is the only one being fed, while the other lower-trophic species being polycultured in this system are expected to "feed-on" inorganic and organic wastes. Like many other deposit-feeding holothurians, sandfish feed on decaying organic matter (OM) in the sediments and can potentially alleviate the deposition of too much wastes from a fed species. However, studies have shown that sea cucumbers seem to have low OM assimilation potential (Orozco *et al*. 2014; Zamora and Jeffs 2011). In some cases, when OM is low to start with, sea cucumber feces can even have higher OM or Total Organic Matter (TOM) levels (**Figure 6**). Sandfish also cannot tolerate very high levels of OM. Initial culture trials in aquaculture ponds and below aquaculture cages with OM reaching >20 % resulted in total mortality for sandfish. Ideally, sandfish will live well in sediments with organic matter of <5 %.

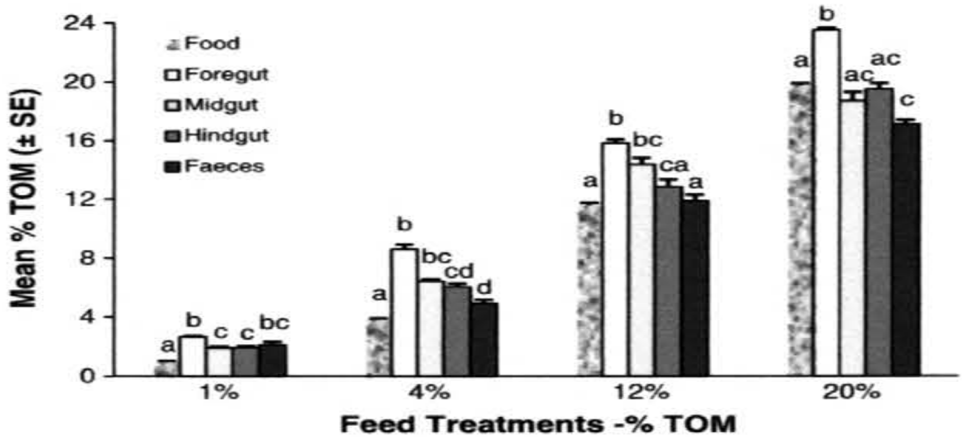

Figure 6. TOM content from food, gut and feces of *A. mollis*.
(Source: Zamora and Jeffs, 2011)

Sandfish promotes bioturbation of sediments as they bury into the substrate, as part of their daily behavior. This potentially aids in oxygenation of the lower sediment layer, much like compared to earthworms in terrestrial soil. In most cases, however, the depth at which sandfish bury is only proportional to its body depth, because they need their anus to still be above the surface for respiration. This depth can only be up to 5 cm for adults and may not be deep enough to really bio-turbate down to the anoxic layer.

The growth of sandfish can be augmented by proximity to aquaculture farms (Dumalan *et al.* 2019), thus the possibility of enhanced growth when polycultured in an IMTA system. However, although sandfish may grow faster, survival may still be low, especially in open and semi-open culture systems like pens or in a sea ranch because of predation and fluctuating environmental conditions.

Concluding Remarks

Sea cucumbers are expensive marine commodities and the aquaculture technologies for species like *Holothuria scabra* or sandfish is rapidly being established. Because of the inherent capacity of sandfish to feed on the organic matter of sediments, they remain a strong candidate for IMTA. However, the prospects for this can be overshadowed by the many challenges that still need to be overcome in order to optimize the growth and survival of this echinoderm in an integrated multi-trophic polyculture system.

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