Aquaculture potential of the tropical sea cucumbers *Holothuria scabra* and *H. lessoni* in the Indo-Pacific region

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Introduction

On the Asian dried seafood market, the sea cucumbers *Holothuria scabra* (sandfish) and *H. lessoni* (golden sandfish) fetch higher prices than any other tropical sea cucumbers. The premium price for processed sea cucumbers has resulted in increased fishing pressure on wild populations of these vulnerable species (Conand 2004). Because of this, in recent years several nations have taken strong management actions to protect the declining sea cucumber fishery (Bell et al. 2008; Friedman et al. 2008).

The attractive price for processed sea cucumbers (called beche-de-mer) and the declining wild fishery has led to considerable interest among private and government agencies in developing alternative methods of producing beche-de-mer, especially through aquaculture (Pitt and Duy 2004; Purcell 2005; Giraspy and Ivy 2005; Eeckhaut et. al. 2008). Sea cucumber aquaculture would provide a permanent solution, making it possible to both enhance declining wild sea cucumber populations through restocking, and provide sufficient beche-de-mer product to satisfy the increasing Asian market demand.

Prospects for farming the tropical *Holothuria scabra* (sandfish) and *H. lessoni*(golden sandfish)

The tropical sea cucumber *H. scabra* makes up some of the largest sea cucumber catches worldwide, and the premium quality beche-de-mer of both *H. scabra* and *H. lessoni* command high prices. This decade has seen significant interest focused on the culture of *H scabra* (Battaglene et. al. 1999; Mercier et. al. 2000; Giraspy and Ivy 2005; Eeckhaut et al. 2008) and *H. lessoni* (Ivy and Giraspy 2006).

Both sandfish and golden sandfish are considered to have the best potential for aquaculture because they have many attributes that make them suitable for hatchery production.

Factors favouring sea cucumber farming in tropical countries

- Well established market acceptance in Asia
- Very high market value and declining wild fisheries
- Availability of suitable species
- Low disease risks
- Availability of commercial technology
- Range of culture systems developed

Suitability of sandfish and golden sandfish for farming

- Wide availability of sandfish species
- Relatively hardy species, adaptable to a range of environments
- Suitable coastal environments
- High water quality (low nutrient content)
- Relatively warm water temperatures
- Large number of potential land-based sites for hatchery
- Potential sea-based sites for grow-out
- High priority industry for public sector research and development staff
- Current and new investment possibilities in hatchery facilities
- Reduced risk through experience gained with commercial production

Commercial technology

Despite the rapid increase in tropical sea cucumber aquaculture research and development activities, commercial expansion has been very slow due to various impediments. One of these impediments is the lack of optimal hatchery management practices for the successful mass production of juveniles in the hatchery.

Hatchery production of sandfish has been carried out at an experimental scale in the Pacific region (Purcell 2004, 2005; Pitt and Duy 2004), with the production of thousands of juveniles. Based on

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these works, a manual for sandfish production was published recently (Agudo 2006).

However, the commercial production of sandfish has only been carried out recently in a few countries such as Australia, Maldives (Giraspy and Ivy 2005) and Madagascar (Eeckhaut et al. 2008). The hatchery technology for the golden sandfish *H. lessoni* was developed by Sea Cucumber Consultancy, Australia (Ivy and Giraspy 2006).

In commercial hatcheries, barriers to mass production of tropical sea cucumbers (e.g. high mortality rates in larval settlement and early juvenile stages) have hampered large-scale production. However, continuous research on effective diets and settlement cues has made significant advances to overcome these barriers and Sea Cucumber Consultancy has been consistently able to produce millions of sea cucumber juveniles in recent years.

Stages in the commercial production of sandfish

1. **Broodstock collection and management**:
   Sea cucumbers are collected by fishers who dive during spawning season, when the gonad index is over seven. Nearly 5 individuals m^{-2} are placed in a flow-through seawater system with dissolved oxygen over 5.5 mg L^{-1} and a feeding rate of 5–7% of body weight.
2. **Spawning stimulation and fertilisation**:
   Spawning inducement is by thermal shock (i.e. temperature raised by 3–5°C). Males spawn first followed by the females (Fig. 1). The diameter of the fertilised egg is around 180 microns (µ). Fertilised eggs hatch into auricularia larvae after 48 hours of fertilisation and start feeding on microalgae.
3. **Larval rearing and feeding**:
   Larvae are reared in 1,000-L fibreglass tanks at a density of 0.5 ml^{-1}. During the larval rearing period the temperature was maintained between 25°C and 27°C, salinity ranged between 37.5‰ and 38‰, while pH remained at 8.2. Larval diet consisted of *Rhodomonas salina*, *Chaetoceros calcitrans*, *C. mulleri*, *Isochrysis galbana* and *Pavlova lutheri* in different combinations and at different stages. The feeding regime depends on the developmental stage, and from the early auricularia to late auricularia stage, microalgal density is gradually increased from 15,000 cells ml^{-1} to 35,000 cells ml^{-1}.
4. **Larval development and settlement**:
   The auricularia larvae develop into doliolaria and pentacula stages before they metamorphose into juveniles. The non-feeding doliolaria larvae are transferred to tanks with settlement cues and the flow-through system is maintained. Early juveniles attach on the settlement substrates in nursery tanks. The corrugated plates with settlement cues facilitate pentacula attachment and juvenile growth.
5. **Nursery phase**:
   The settled juveniles spend three to four months in nursery tanks, and several kinds of feeds are used for the growing juveniles. Juveniles that are 5–7 cm (Fig. 2) are ready to sea ranch or grow out in ponds.
6. **Sea ranching and pond grow-out**:
   The keys to successful sea ranching are site selection and routine management. Sea cucumber juveniles are sea ranched in sheltered bays with sea grass. Areas with few predators, such as sea stars and crabs, are preferred for successful sea ranching.

Juveniles that are 5–7 cm can be grown successfully in ponds with required water exchange. Monitoring water quality parameters and growth characteristics are essential during the grow-out phase. Sea cucumbers in grow-out areas are ready to harvest 12 months after release (Fig. 3).

Technical service

The Sea cucumber Consultancy Company (registered in Queensland, Australia), offers dedicated consultancy and management service on all aspects of sandfish commercial production. Sea Cucumber Consultancy is first of its kind and has the technology to produce millions of tropical sea cucumber juveniles in a season. This technology has developed as a result of significant research during the last 15 years mainly in the fields of spawning inducement, larval culture and settlement and juvenile grow out. The commercialisation of sea cucumber aquaculture in the Maldives and Australia has taken a significant step forward with the Sea Cucumber Consultancy's efforts.

Sea Cucumber Consultancy provides hands-on training for the mass production technology transfer in following stages of sea cucumber aquaculture project development.

Prefeasibility study

This is the preliminary stage for the development of sea cucumber aquaculture project. A prefeasibility study is carried out to determine the scope of success for a potential sea cucumber business in a specific area. During the study, the suitability of natural resources such as water, land, climate and other parameters of the proposed project sites are analysed

Feasibility study

If the prefeasibility study is favourable for sea cucumber aquaculture, then a full feasibility study is

required. In this step, an appropriate and site-specific aquaculture system is developed and production target is forecasted. An estimate for constructing and operating an aquaculture facility are also determined.

Sea cucumber farm design and engineering

The actual design for the commercial sea cucumber aquaculture facility starts at this stage. Simultaneously with the feasibility study and detailed topographic study of the selected site, the design of the facility (plans of the hatchery, nursery, live feed production unit, water treatment systems, buildings, layouts of water and air distribution system) are defined. The final project cost is determined at this stage.

Aquaculture facility construction

The technical follow-up during construction determine the quality and good execution of technical works. In addition, the selection of the technical personnel suitable for the work begins.

Technology transfer

In order to safeguard the smooth operation of the facilities, technical protocols are compiled and training for hatchery, nursery and farm management staff are provided in different stages during the first production cycle. Technical support continues until the first harvest.

Management

Besides the design and construction of a sea cucumber hatchery and farm, the management of hatchery and farm and grow out are provided on an *ad hoc* basis.

Technical advice and training

Technical advice is based on assessments of the technical and management aspects of hatchery and farming operations, to improve the production protocols and management procedures.

Figure 1. Female *Holothuria scabra* releasing eggs.

Figure 2. Twelve-week-old sea cucumber juveniles ready for grow out.

Figure 3. Twelve-month-old adult sea cucumbers ready for harvesting.

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