Nursery Performance of Sandfish *Holothuria scabra* Juveniles in Tidal Earthen Pond Using Different Types of Cage

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Abstract. Sandfish *Holothuria scabra* is a promising aquaculture commodity. Techniques for producing this species have been developed rapidly in recent decades to address the issues of increasing market demand and overexploitation of wild populations. Providing sandfish seed with suitable size for stocking (20-50 g) is one of the main issues in mass production of sandfish. Developing reliable nursery techniques could solve this problem. This study aimed to investigate the survival and growth performance of sandfish juveniles in two types of nursery cage: (i) floating net cages and (ii) fixed net cages. The experiments were conducted in a tidal earthen seawater pond in Sekotong, West Lombok for 14 weeks between August 5 and November 13, 2015. Each type of experimental cage had 3 replicates, stocked with 15 juveniles (mean initial weight 4.22 g) per cage. Feed was provided naturally from the substrate in the pond and in seawater, which was exchanged daily following the natural tidal cycle. Juveniles showed rapid growth and high survival rate for both floating and fixed net cages during the first six weeks of culture with no significant difference (P<0.05). Conversely, at the end of the experiment, the growth and survival of juveniles in the fixed net cage were lower because of the extreme low tide and the dry season, which began after week 6. During the low tide, floating net cages stayed submerged in the water while some parts of the fixed cages were exposed, killing the juveniles attached to the net. Our findings suggest that both cages were suitable for use in sandfish juvenile nurseries, although it is better to use the floating net cage in tidal ponds.

1. Introduction

The sea cucumber *Holothuria scabra*, known as sandfish, is one of the tropical sea cucumber species that have high market value and demand [1,2]. Besides, this commodity has been traded for centuries as an exclusive delicacy mainly in the dried form, known as beche-de-mer or trepang. The price of this product differs greatly depending on several factors, mainly size and product quality. In Hong Kong, the price for extra-large dried sandfish with premium quality was over US$ 1.800 kg$^{-1}$ [2]. Recently, sea cucumber stock declines sharply due to the catches have risen globally and overexploitation [3,4]. On the other hand, as the other option to meet the increasing demand, sandfish aquaculture began to develop in recent years.

Development of sandfish aquaculture techniques has grown rapidly in each aquaculture sub-sector such as broodstock management, spawning, larval rearing, juvenile nursery, and grow-out phase. The Research and Development Division for Marine Bio Industry of Indonesian Institute of Sciences (LIPI) has researched sandfish aquaculture since 2011 and is able to mass-produce sandfish juvenile in
the capacity of 100,000 juveniles year\(^{-1}\). However, following the hatchery phase which produces larvae and juveniles, an effective nursery and grow-out method are urgently needed. In the nursery, the juveniles would be reared to the suitable size (approximately 20-50 g ind\(^{-1}\)) before being released into the grow-out phase. This range of size is preferable because it has a better chance to survive predation, tends to be more adaptive to the environment, and takes a relatively shorter time to reach marketable size [5].

There are several approaches for sandfish juvenile nurseries such as indoor rearing in tanks, outdoor rearing in tanks [6], rearing in ponds [7] or the ocean [8]. Some research has suggested that juvenile rearing in the earthen seawater pond is the best option. According to Purcell et al. [7], the most effective environment for nursery and juvenile rearing of sandfish was in earthen ponds. In Indonesia, there are more than 258,000 ha of idle ponds which are mostly earthen pond initially used for shrimp farming. Some of them are seawater ponds in which the water is sourced directly from the sea through pipelines or inlet or the canals. This kind of pond is highly influenced by the tidal cycle to exchange the water in the pond.

The information and practical knowledge related to the sandfish nursery system in seawater earthen pond powered by the tidal cycle is relatively limited. Several factors may influence the performance of a nursery system, such as pond condition and type of enclosure used to keep the juveniles. This study aimed to analyse the type of cage suitable for juvenile rearing in seawater earthen ponds powered by the natural tidal cycle. We tested two types of cage for the nursery phase: (i) floating net cages and (ii) fixed net cages.

2. Methodology

2.1. Research Design and Rearing Method
We used hatchery-produced juveniles from the Research and Development Division for Marine Bio Industry of the Indonesian Institute of Sciences (LIPI). A total of 60 juveniles with an initial mean weight of 4.21 ± 0.01 g were reared for 14 weeks (August 5-November 13, 2015) in an earthen seawater pond located in Sekotong, West Lombok using two types of cage which were: (i) floating net cage and (ii) fixed net cage (Figure 1). The net cages were made from with 1 mm mesh nylon net, and the volume of the submerged part was 100 cm x 100 cm x 50 cm. Each treatment was conducted in triplicates and stocked with 15 juveniles. Feed was provided naturally from the substrate in the pond and seawater, which underwent daily exchanges following the natural tidal cycle.

![Figure 1](image-url)

**Figure 1.** a) Pond location in Lombok Island; b) Layout of ponds in Sekotong Bay; c) Fixed and floating experimental net cages in the earthen seawater pond; d) Sandfish juveniles.

2.2. Data Collection
Juveniles from each experiment unit were assessed for their survival, and individual weight was measured every two weeks as well as water quality in the experiment pond. At the end of the experiment, the survival rate (SR), the weight gain (WG), the specific growth rate (SGR) and the final biomass (FB) of juveniles were estimated following [8,9]:

\[
\text{SR} = \frac{\text{Final number of juveniles}}{\text{Initial number of juveniles}} \\
\text{WG} = \frac{\text{Final weight} - \text{Initial weight}}{\text{Initial weight}} \\
\text{SGR} = \frac{\ln \left( \frac{\text{Final weight}}{\text{Initial weight}} \right)}{\text{Time}} \\
\text{FB} = \frac{\text{Final weight}}{\text{Water volume}} 
\]
SR = (Nt/No) \times 100\% \quad (\text{Eq. 1})

where SR is the survival rate (%), Nt and No are the final and initial numbers of juveniles, respectively.

WG = ((Nt-No) / No) \times 100\% \quad (\text{Eq.2})

where WG is the weight gain (%), Nt and No are the final and initial numbers of juveniles, respectively.

SGR = 100 \left( \frac{\ln Wt - \ln W0}{t} \right) \quad (\text{Eq.3})

where SGR is the specific growth rate (% per day), W0 is the initial wet weight (g), Wt is the final wet weight (g), and t is the length of the culturing period (days).

FB = Wt \times Nt \quad (\text{Eq.4})

where FB is the final biomass (g), Wt is the final wet weight (g), and Nt is the final number of juveniles.

2.3. Statistical Analysis
Data on the effect of various rearing conditions on the growth performance of juvenile *H. scabra* were analysed with a one-way analysis of variance (ANOVA) at a significance level of 0.05 using the SPSS software (version 25). The Tukey post hoc test was applied to investigate any significant difference between treatments.

3. Results and Discussion
The *H. scabra* juveniles grew well in the pond nursery system even without feeding. This result matched with [10] who discovered that sea cucumbers in the earthen pond achieved quick growth by consuming the organic matter in sediments. The general trends observed in this study showed that the performance of both cage types was relatively similar at the beginning but started to show different results after week 10.

The survival rates of *H. scabra* juveniles were high and stable during the first eight weeks. The survival rates in both cage types during this period were higher than 90% with no significant difference (P<0.05). However, starting from week 10, the number of juveniles in both cage types began to decrease (Figure 1).

![Figure 2. Survival rate of *H. scabra* juveniles in the floating and fixed cages.](image-url)
Mortality in the fixed cage was higher than the floating cage causing a significant difference (P>0.05) in survival at the end of the experiment. The final survival rate of *H. scabra* juveniles in the fixed cages was 31.11 ± 3.85%, almost half the survival rate in the floating cages net (75.56 ± 10.18 %) (Table 1). The reported survival rates of *H. scabra* juvenile during the nursery phase and grow out in pond and sea vary. Survival was reported at 56% after 41 days [10] and 80% after 420 days [11] in Vietnam. A nursery which conducted grow-out in marine ponds with nets called *hapa* nets reported survival 57% after 30 days [12] and 80% after 162 days [8]. Furthermore, survival was 69% after 360 days [13] and 84% after 35 days [14] in New Caledonia. Compared to previous studies, the survival rates in our study can be considered acceptable.

**Table 1.** Growth parameters of *H. scabra* juveniles at the sixth and 14th weeks of the experiment.

| Parameters                  | Week 6          | Week 14          |
|-----------------------------|-----------------|------------------|
|                             | Floating Cage   | Fixed Cage       | Floating Cage | Fixed Cage |
| Final Weight (g)            | 13.69 ± 1.06a   | 13.20 ± 0.95a    | 7.49 ± 0.66a  | 7.09 ± 1.30a |
| Weight Gain (%)             | 225.03 ± 26.24  | 213.35 ± 23.53   | 77.88 ± 15.99 | 68.36 ± 31.20 |
| Specific Growth Rate (% d⁻¹)| 2.67 ± 0.19a    | 2.59 ± 0.17a     | 0.57 ± 0.99a  | 0.50 ± 0.19a  |
| Survival Rate (%)           | 95.56 ± 7.70a   | 93.33 ± 6.67a    | 75.56 ± 10.18 | 31.11 ± 3.85b |
| Final Biomass (g)           | 195.86 ± 16.85   | 190.00 ± 27.66a  | 85.55 ± 9.54a | 33.10 ± 7.75b |

A similar trend was also observed in the growth patterns of *H. scabra* juveniles in this study (Figure 2). We found that the mean body weight of juveniles in both cage types increased significantly during the first six weeks, which also indicated high growth. The weight gain during this period was more than two-fold compared to the initial weight (Table 1). After that, the growth rate was relatively slow, and the mean body weight remained much the same until week 10. From week 10 to 14, the growth of the juveniles was negative, and the mean body weight decreased to 7.49 ± 0.66 for the floating net cages and 7.09 ± 1.30 for the fixed net cages. Although the mean body weight fluctuated, the difference between fixed and floating net cages was not significant (P<0.05).

![Figure 3](image-url)  
**Figure 3.** Mean body weight of *H. scabra* juveniles in the floating and fixed net cages

The combination of growth and survival influenced juvenile biomass. In this study, we found that the biomass of juveniles increased during the first six weeks, remained relatively stagnant during weeks 6-10, and then decreased until the end of the experiment (Figure 3). This trend was similar in both cage types, and no significant difference (P<0.05) was observed except in week 14. The final
juvenile biomass in the fixed net cages was significantly lower (P<0.05), around half the juvenile biomass in the floating net cages. This result was mainly influenced by the low survival of juveniles in the fixed net cages during week 14.

![Figure 4](image)

**Figure 4.** Total Biomass of *H. scabra* juveniles on the floating and fixed net cage.

Our study revealed that when the pond condition was stable, there was no performance difference between the floating and fixed net cages. However, if the environmental conditions fluctuated, the results could be different. During the first six-weeks, pond temperature and salinity were relatively stable. This condition allowed optimum growth and relatively high survival in both cage types. After week 6, the tidal cycle changed. During this period, there were very low tides observed in the surrounding waters. Fresh seawater could not enter the canals due to the low water level, and as a result, for several weeks there was no water exchange in the experimental pond. Combined with high sunlight intensity and low rainfall (Figure 5), the pond water level dropped by 20 cm while the temperature and salinity increased (Table 2). Higher temperature and salinity can cause growth to slow down even cause negative growth [15,16] such as that observed in the last four weeks.

**Table 2.** Water quality and water depth.

| Parameters               | Period             | Period               |
|--------------------------|--------------------|----------------------|
|                          | Week 0-6           | Week 8-14            |
| Salinity (g l⁻¹)         | 35.50±1.75; 34.50-36.00 | 39.75±2.45; 38.50-41.00 |
| Temperature (°C)         | 29.12±0.38; 28.68-29.89 | 34.25±2.34; 33.85-35.55 |
| pH                       | 8.08±0.14; 7.89-8.12 | 8.12±0.17; 8.05-8.21 |
| Dissolved Oxygen (mg l⁻¹) | 5.25 ± 0.70;       | 4.97 ± 1.06;        |
| Water Depth (cm)         | 78.25 ± 5.85       | 52.45 ± 12.55       |
Figure 5. Monthly total rainfall (mm) in Sekotong, West Lombok during 2015. Source: Meteorological, Climatological, and Geophysical Agency of Indonesia.

The juvenile sandfish in the two cage types showed no significant differences in terms of body weight. Therefore, technically the type of cage did not have an effect on the growth pattern and body weight. As for the lower survival in the fixed net cage at the end of the experiment, it may have been caused by different technical specifications of the two cage types. The position of the floating net cage could be adjusted when pond water level fluctuated, to ensure that the juveniles stayed submerged in the water. Conversely, in the case of the fixed cage, some portion of the fixed net cage may be exposed during low tides. This situation can directly kill any juveniles that remain attached to the exposed net surface or slowly kill the juveniles because of the higher density in the area where water still remained. The technical advantages of floating cages also make this type of cage more suitable for ocean nurseries [8], where the water level fluctuates following the tidal cycle.

4. Conclusion
Our findings suggest that both types of net cage (hapas) were suitable for use as sandfish juvenile nurseries. However, it is better to use the floating net cage in the tidal ponds or any area in which the water level may fluctuate following the tidal cycle.

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