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FULL PAPER

First-phase juvenile rearing of the sea cucumber *Holothuria scabra* in Eastern Samar, Philippines

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ABSTRACT

Experiments were conducted to optimize the nursery rearing methods for the sea cucumber *Holothuria scabra* at the BFAR-GMFDC, Eastern Samar. The growth performance and survivorship of juveniles were compared in different locations, seasonality, stocking densities, and rearing media. For the experiments on location and seasonality, nursery rearing was conducted in Guiuan and in Salcedo, Eastern Samar during April-May, July-August, and September-October 2018. The mean total weight gain (TWG) and specific growth rate (SGR) of juveniles were significantly better in Guiuan (3.78 g and 13.09%.d^{-1}, respectively) compared to Salcedo (1.997 g and 11.70%.d^{-1}, respectively) ($p<0.05$). However, survival rates were significantly higher in Salcedo (75.67%) compared to that of Guiuan (66.89%) ($t=-1.732$, $p>0.05$). Predatory crabs and parasitic isopods (*Cymodoce sp.*) infiltrated the net cages in Guiua, which increased the mortality of juveniles. Highest growth and survivorship were observed during dry months in April-May 2018 (TWG of 3.71 g, survival of 71.39%) but were lowest during the wet season in September-October 2018 (TWG of 2.26 g, survival of 70.89%). However, the growth and survival results did not significantly differ among different months ($p>0.05$). For the experiment on stocking density, juveniles stocked at 300 ind./cage had the highest growth (TWG of 5.19 g, SGR of 13.86%.d^{-1}) while juveniles at 1000 ind./cage had the lowest growth (TWG of 1.28 g, SGR of 10.70%.d^{-1}) ($p<0.05$). Survival rates of the juveniles in 300 ind./cage were also highest (80.30%). This study recommends stocking juveniles at 500 ind./cage since survival at this density did not significantly differ with that of 300 ind./cage ($p>0.05$). In terms of rearing medium, growth was better in floating net cages (TWG of 2.60 g, SGR of 11.67%.d^{-1}) compared to indoor tanks (TWG of 0.18 g, SGR of 6.38%.d^{-1}). However, indoor tanks yielded higher survival rate (67.83%) than floating net cages (56.11%) ($p>0.05$). Higher mortality in net cages was caused by intruding predators and fluctuations in water quality.

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1. INTRODUCTION

Holothuria scabra is highly valued and heavily exploited sea cucumber species in the Philippines (Olavides et al. 2010; Schoppe 2000). Aquaculture has become a solution to the depleting wild stocks to meet market demands (Battaglene 1999). Seed production techniques have been improved in the past five years at the sea cucumber hatchery of the Bureau of Fisheries and Aquatic Resources – Guiuan Marine Fisheries Development Center (BFAR-GMFDC) in Eastern Samar. However, nursery and grow-out cultivation of the hatchery-reared *H. scabra* in the region have not been well-explored under experimental conditions. Considering the geographic location of Eastern Samar, the environmental and eco-biological features could differ compared to the hatcheries in other parts of the country. These several environmental factors are vital in the cultivation not only for sea cucumbers but also for other aquatic commodities.

Seed production involves a systematic scheme which begins with larval rearing in tanks followed by nursery rearing. Nursery rearing is a critical phase since early juveniles measuring ≤1 mm are very vulnerable to handling and high density. Juveniles can be grown in larger tanks, pools or raceways with flow-through systems and should be fed with diatom cultures, dried algae, seaweed paste or fine-grade starter shrimp pellet (Gamboa et al. 2004; Agudo 2006). Rearing can also be conducted in open sea nursery systems, which can be modified into either floating open-top net cages or bottom-set hapa net cages (Juinio-Menez et al. 2012). In this setup, alternative feed is not anymore needed since microalgal film and organic detritus, which the animals forage on, accumulate on the sides and bottom of the cage. At the sea cucumber hatchery of BFAR-GMFDC, indoor tanks have been utilized during the preliminary trials in juvenile rearing. However, this rearing medium has been replaced with outdoor net cages because it was not economical, and space for juvenile tanks was a problem in the hatchery.

After the first phase nursery, an intermediate phase rearing is conducted where the animals are conditioned with natural sediments; hence, the process called sand-conditioning. This method has shown an increase in the survival rate of juveniles (Juinio-Menez et al. 2012). Grow-out culture is conducted after sand-conditioning of juveniles. Suitable and well-managed sea ranch areas should be selected before grow-out. Sea cucumbers are released for grow-out and are retrieved after 9 to 12 months when they have reached sexual maturity and marketable size weighing not less than 320 g. Subsequent harvesting can also be done after 6 months. It has been recommended to have programmed releases and selective harvesting (>320 g) in order to maintain viable broodstock population in the sea ranch, elevating ecological and economic yields (Juinio-Menez et al. 2012).

As the main sea cucumber hatchery in the Eastern Visayas, production of viable seeds at the BFAR-GMFDC should be amplified to suffice the needs of reseeding and stock enhancement programs of BFAR. Techniques in nursery rearing should also be optimized to reduce hatchery expenses. Moreover, the type of applicable nursery system and the seasonality of rearing must also be explored in areas like Eastern Samar, where variability in weather conditions become crucial to survivorship of the sea cucumber stocks. Likewise, some problems in the hatchery should also be addressed and provided with interventions to attain successful and sustainable production. Specifically, this study aims to determine the growth and survival of sea cucumbers reared at different locations in Eastern Samar, at different times of the year, and in different stocking densities and rearing media.

2. MATERIALS AND METHODS

2.1 Spawning and Larval Rearing

Healthy broodstocks with an average body weight of 247.63 ± 28.20 g (mean ± SD, n=25) were collected from the marine protected areas of Guiuan and were held in sea pens at the sea cucumber hatchery of BFAR-GMFDC a week prior to spawning. Spawning trials were done during the days of the full moon or new moon as the putative lunar schedule for spawning of sandfish. Induced spawning was employed in this study using dry treatment and food shock technique following the methods described by Juinio-Menez et al. (2012) but with the omission of thermal shock. Dry treatment was done by blot-drying using a dry towel and then air-drying the animals in a large basin for 45 minutes. Afterward, the broodstocks were immersed in a basin with a 0.1 g/L *Spirulina* powder – seawater mixture for another 45 minutes (Agudo 2006). After spawning induction, the broodstocks were then transferred in a 1000-L tank with sand-filtered seawater and aeration and were allowed to spawn. Male and female gametes were collected separately and were placed together in a clean, transparent 50-L plastic container to allow fertilization to occur. After an hour, the fertilized eggs were collected by sieving and were counted under a microscope using a Sedgewick Rafter counting chamber.

Fertilized eggs were incubated for two days in a 60 L-plastic container with UV-treated seawater at a temperature of 28.15 ± 2.65°C and salinity of 32.31 ± 3.87 ppt (mean ± SD). Larval tanks were provided with an aeration system, corrugated plastic plates for settlement of pentactula larvae (which usually develop on Day 15), and were covered with a black net for shading. Water replenishment was done every other day at a 50% rate. Larvae were fed with 1:1 density of combined *Chaetoceros gracilis* and *Chaetoceros calcitrans* microalgal diet which was acquired from the Phycology Laboratory of BFAR-GMFDC. The combined *C. gracilis* and *C. calcitrans* diet has been an accustomed feed for sea cucumber larvae and has been proven to yield good growth, development, and survival of the larvae (Cabacaba et al. 2017). The larvae were held at a water temperature of 27.83 ± 4.55°C, salinity of 31.49 ± 3.62 ppt, pH of 9.03 ± 0.03, and dissolved oxygen of 4.11 ± 0.26 $g.L^{-1}$, and were allowed to develop until early juvenile stage (>1 mm) for 30-35 days.

2.2 First Phase Juvenile Rearing

Spatiality-seasonality experiment on juvenile rearing: Larvae were expected to have developed into early juveniles (>1 mm) after 30-35 days of rearing. First phase juvenile rearing was conducted in an ocean nursery system at the BFAR-GMFDC hatchery in Guiuan (11° 1'7.7" N, 125° 42' 39.4" E), and at the nearby waters of Maliwaliw Island in Salcedo, Eastern Samar (11° 5' 33.7" N, 125° 34' 46.9" E). A total of 300 juveniles were reared per floating hapa net cage, which has a dimension of 1 x 1 x 0.3 m (length x width x depth). Three 1.54 mm and average initial body weight of 0.01 ± 0.03 g (mean ± SD). The juveniles were regularly monitored, and the hapa nets were cleaned as needed when algal biofilm over-accumulate the sides and the bottom of the nets. First phase juvenile rearing trials were conducted in both sites mentioned above for 45 days in separate batches, during April-May, July-August, and October-November, 2018.

Different stocking densities: Juveniles were also reared at different stocking densities (300, 500, and 1000 ind./cage) in a separate experiment. Three replicates were produced for each stocking density, and two trials of the experiment were conducted in April and in August 2018 at the BFAR-GMFDC hatchery.

Rearing tanks versus hapa net cages: Another separate experimentation was conducted to compare the growth and survival of juveniles in indoor tanks and outdoor floating hapa net cages. The wooden rearing tanks (1 m x 1 m x 0.3 m; length x width x height) were provided with aeration and flow-through system. Settlement plates thinly smeared with *Spirulina* paste were also supplemented for the attachment of juveniles. Moreover, *Sargassum sp.* and *Laurencia papillosa* crude extract mixture (500 g seaweed per 50 L sand-filtered seawater) was fed to the juveniles at a rate of 6 L.d-1 for 45 days. Simultaneously, juvenile rearing was also conducted in an open-ocean nursery system. Ocean nursery rearing of juveniles was held in floating hapa net cages with a dimension of 1 m x 1 m x 1.5 m (length x width x depth). Juveniles with the length of >1 mm were stocked at 300 individuals per cage for consistency. Juveniles in hapa net cages were not fed with seaweed extracts since accumulates of organic detritus would be the source of nourishment. The setups, both in rearing tanks and floating hapa nets were

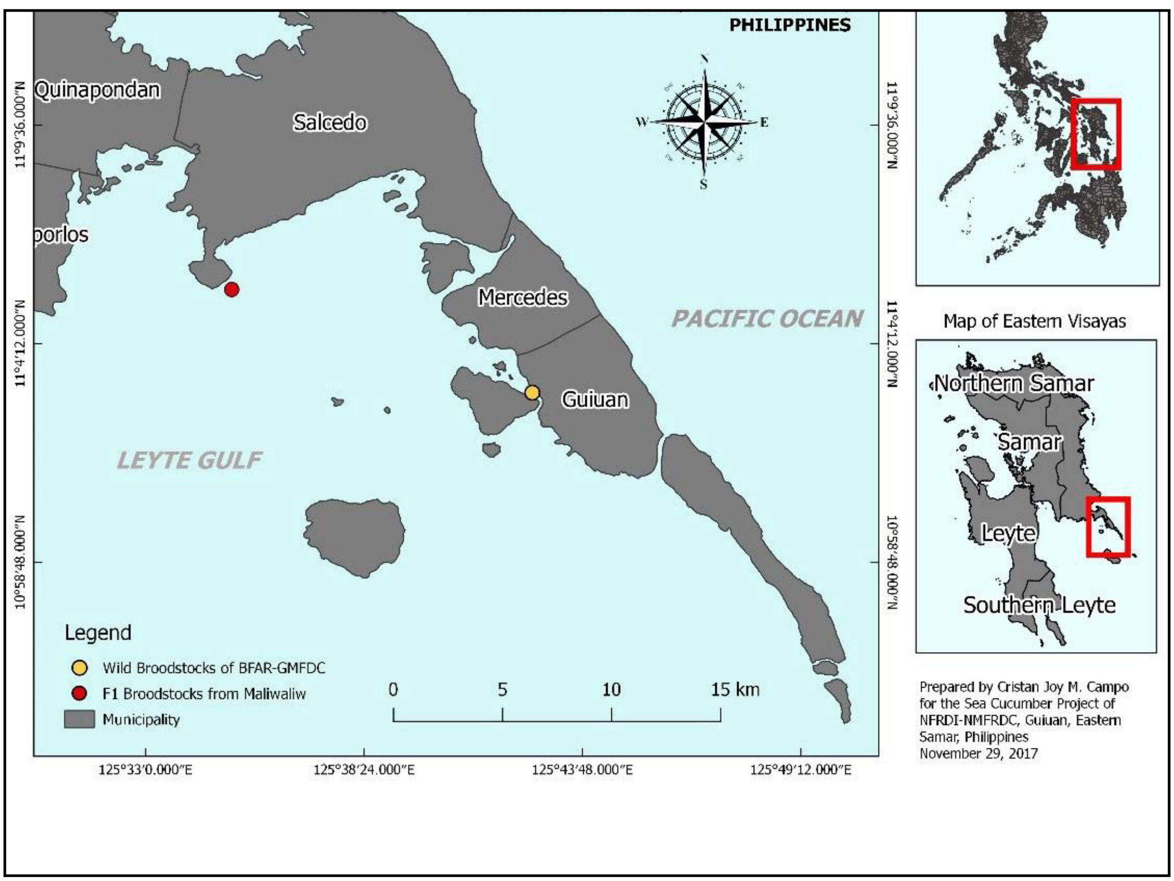

Figure 1. Site map for nursery rearing of Holothuria scabra in Guiuan and Salcedo, Eastern Samar.

conducted in triplicates, and two experimental trials were conducted in May and in September 2018.

2.3 Growth and Survival Assessments

The growth performance of juveniles in all of the experimental setups was assessed by measuring the individual wet weight using an analytical balance. Initial and final weight measurements were determined, and growth parameters, including total weight gain (TLG/TWG) and specific growth rate (SGR), were calculated. The survivorship was determined by calculating the survival rate of juveniles, which is the percent of the total count of harvested viable sea cucumbers in every setup.

2.4 Data and Statistical Analysis

Descriptive and inferential analysis of data was done using IBM® SPSS® Statistics version 21. Means, standard deviation, and standard error of the means were calculated and presented in tables and graphs. Data transformation was also applied to count data by using arcsine or square- root transformation. Statistical differences among the different treatments were determined using single-factor ANOVA for one independent variable test, two-factor ANOVA for two-independent variable tests (location and seasonality of nursery rearing), with Duncan Test as post hoc test. Independent sample t-test was also run for comparing two variables.

3. RESULTS AND DISCUSSION

3.1 Juvenile rearing in Guiuan and Salcedo

The juveniles reared in Guiuan had better growth performance with average total weight gain (TWG) of 2.52 – 6.27 g and specific growth rate (SGR) of 12.30 – 14.31%.d^{-1}. On the other hand, juveniles in Salcedo had lower TWGs which ranged from 1.25 – 3.24 g, and SGR of 10.75 – 12.85%.d^{-1} only. Using independent sample t-test, the average results for growth were statistically different in both sites (Table 1). However, the survival rates of juveniles between the sites did not parallel with that of the growth results. Mean survival rate in Salcedo was higher (75.67 ± 10.44%) compared to the mean survival rate in Guiuan (66.89 ± 11.05%), although, the results were not statistically different, t=-1.732 and p=0.103.

Table 1. Descriptive statistics and t-test results for growth and survival of H. scabra juveniles in Guiuan and Salcedo, Eastern Samar.

	Groups		95% CI for Mean Difference			
	Guiuan (Mean ± SD)	Salcedo (Mean ± SD)		t	df	p-value
Total weight gain (g)	3.78 ± 1.31	1.997 ± 0.60	1.786	3.721	16	0.002
Specific growth rate (%.d-1)	13.09 ± 0.72	11.70 ± 0.63	1.384	4.347	16	< 0.001
Survival (%)	66.89 ± 11.05	75.67 ± 10.44	-8.778	-1.732	16	0.103

The growth of juveniles depends on the quality and quantity of epibenthic microalgae and detritus, which accrue on the sides and bottom of the hapa net cages (Purcell 2012). Although this aspect was not well-investigated in this study, historical data and physical observations of the algal biofilm in the hapa net cages could help elucidate the growth performance of the juveniles in both sites. According to Rakestraw (1936), nitrogen and phosphorus compounds are critical to microalgal growth. Water quality in the sea cucumber open ocean nursery system of BFAR-GMFDC was investigated in 2017 and results on nitrite and nitrate concentrations were 0.008 mg.L^{-1} and 1.40 mg.L^{-1}, respectively. This was slightly higher than what was recorded in Salcedo with 0.006 mg.L^{-1} for nitrite and 0.9 mg.L^{-1} (Cabacaba and Campo 2017).

Moreover, the water in the open ocean nursery system in Guiuan site was more turbid and murkier than in Salcedo. The turbidity of water contributes to the accumulation of organic detritus, which was observed in the thicker algal biofilm in the hapa nets in Guiuan. The higher concentration of nitrogen compounds and turbidity of seawater in Guiuan site could be attributed from the excess feeds of the adjacent fish cages of BFAR hatchery and the presence of human settlement nearby. In Salcedo, the rearing area was remote to human settlement, and no commercial hatchery was established. Therefore, the influence of environmental features and urbanization on sea cucumber aquaculture needs a separate investigation.

The low survival rate of juveniles in Guiuan site was due to the infiltration of predators and parasites in the hapa net cages. Crabs and crab instars were observed to infest the outdoor net cages. According to Lavitra et al. (2009), crab species critically increased the mortality of sea cucumber juveniles by predation. The minuscule isopod *Cymodoce* sp. also infested sea cucumber hapa net cages in Guiuan throughout the year but were most prevalent during the summer

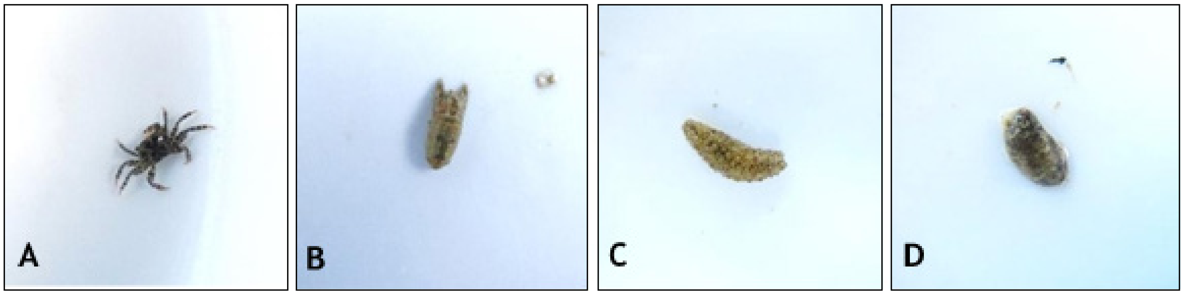

Figure 2. (A) Juvenile crab predatory to sea cucumber juveniles, (B) Cymodoce sp. responsible to skin infection of juveniles (C) A healthy sea cucumber juveniles with the intact epidermis (D) An infected sea cucumber juvenile with a skin infection and visible white spots on the epidermis.

season. Their effect on survivorship of juveniles was not well-investigated in this study, but according to Lavitra et al. (2009), the isopod was responsible for skin infection in juveniles which was also detected in this study. The histological study conducted by Lavitra et al. (2009) has shown that the infection has caused the destruction of the cuticle and the epidermis, particularly in the upper connective tissue of the sandfish juveniles. They also reported that there were holothurian spicules found inside the gut of the isopod *Cymodoce* sp., implying that these isopods were feeding on the epidermis of the juveniles. The juveniles also have developed off-plate syndrome where they lost the ability to attach to the available substrate, became covered with mucus and eventually disintegrated. During the conduct of this study, the isopods and the crabs were manually removed to lessen mortality. The floating hapa net cages were also regularly monitored and were changed once for each trial.

3.2 Effect of seasonality on nursery rearing

The highest growth performance was observed during April-May batch of rearing with an average total weight gain of 3.71 g and a specific growth rate of 12.95%.d^{-1} (Table 2). On the other hand, the lowest growth performance of juveniles was observed during the rearing in October-November with an average TWG of 2.26 g and SGR of 12.02%.d^{-1}. The results did not differ significantly (p>0.05).

The highest survival rate of juveniles was observed during the rearing in July-August 2018 with an average result of 71.56%, followed by April-May 2018 with 71.39%, and lastly by October-November 2018 with 70.89% only. However, the differences among the mean survival were not statistically significant (Table 3, *F= 0.005*; p = 0.995).

The warmer temperature was experienced in Eastern Samar in 2018 during the dry season with the peak month in May with an average temperature of 33°C (AccuWeather 2018). Successful rearing activities with high survival yields were also reported by Juinio-Menez et al. (2012) during the dry months in Bolinao, Pangasinan in the northern part of Luzon, Philippines. Gamboa et al. (2012) also reported higher survival of juveniles reared during the first quarter of the year but lowered during June and October. Perhaps aquaculture activities would be more productive

Table 2. Mean (± SD, n = 6) total weight gain, specific growth rate, and survival rate of *H. scabra* juveniles reared during different times of the year.

	April-May	July-August	September-October
Total weight gain (g)	3.71 ± 1.73 a	2.70 ± 1.29 a	2.26 ± 0.43 a
Specific growth rate (%.d-1)	12.95 ± 1.02 a	12.21 ± 1.16 a	12.02 ± 0.46 a
Survival	71.39 ± 13.83 a	71.56 ± 11.02 a	70.89 ± 11.24 a

Note: Similar letters show no significant difference using the Duncan post hoc test (subset for alpha = 0.05)

Table 3. One-way ANOVA Table on total weight gain, specific growth rate, and survival rate of *H. scabra* juveniles reared during different times of the year.

		Sum of Squares	df	Mean Square	*F*	p-value
Total weight gain	Between Groups	6.634	2	3.317	2.048	0.164
	Within Groups	24.294	15	1.620		
	Total	30.928	17			
Specific growth rate	Between Groups	2.924	2	1.462	1.686	0.219
	Within Groups	13.005	15	.867		
	Total	15.929	17			
Survival rate	Between Groups	1.444	2	0.722	.005	0.995
	Within Groups	2194.835	15	146.322		
	Total	2196.280	17			

during the dry season since high microalgal biomass occurs during warmer days, which would benefit sea cucumbers (Hancke et al. 2014).

3.3 Effects of the interaction between location and seasonality

A two-factor ANOVA was conducted to examine the effect of location and seasonality of rearing on the growth performance and survivorship of *H. scabra*. Growth performance (TWG and SGR) of juveniles was not influenced by the differences in rearing site and seasonality. The summary of the F-values and p-values from the two-factor ANOVA is presented in Table 4. Likewise, the interaction between location and seasonality did not significantly affect the survivorship of *H. scabra* juveniles ($F = 0.497$, $p = 0.621$).

Table 4. Two-way ANOVA results on the effects of site, seasonality, and site-seasonality interaction on the growth performance and survivorship of H. scabra juveniles.

	Location		**Seasonality**		**Location*Seasonality**	
	F- value	*p- value*	*F- value*	*p- value*	*F- value*	*p- value*
Total weight gain	24.499	< 0.001	5.664	0.019	2.493	0.124
Specific growth rate	35.541	< 0.001	6.024	0.015	3.024	0.086
Survival Rate	2.434	0.145	0.018	0.982	0.497	0.621

Eastern Samar experiences Type II climate (PAGASA 2018). The area experiences almost no dry season, and a very pronounced maximum rainy season from November to January. During the wet season, the amount of rainfall and the probability of experiencing weather disturbances such as tropical depressions and typhoons are relatively higher (PIDS 2005). During 2018, typhoon *Ompong* (Mangkhut) and typhoon *Paeng* (Trami) hit the eastern Philippines including the province of Eastern Samar during mid- and late-September. This has caused drastic changes in water physico-chemical conditions, which resulted to stress in the juveniles, thus, lowering survival yield.

The effects of location and seasonality of nursery rearing on the growth performance and survivorship of juveniles were however limited in this study since only two sites were studied and the seasonality was only observed in a single year. Thus, a more robust data on spatiality and seasonality could have been produced if nursery rearing was done in additional sites and if was done throughout the year for several years for replicability. Nevertheless, the results of this study reflect the actual experiences on nursery rearing in both Guiuan and Salcedo, two distinct sites with different quality of the environment, and nursery rearing activities conducted in the year 2018 during which several weather disturbances have occurred.

3.4 Different stocking densities

The juveniles stocked at 300 ind./cage had the best growth performance (TWG of 5.19±0.44 g and SGR of 13.86 ± 0.17%.d^{-1}) while the stocking density of 1000 ind./cage has yielded lowest growth results (TWG of 1.28 ±0.15 g and SGR of 10.70 ± 0.32%.d^{-1}) as shown in Figure 3. Survival rates of the juveniles in 300 ind./cage were also highest (80.28 ±4.70%). This was followed by 500 ind./cage with 74.97 ±5.20% survival rate of juveniles, and lastly by the result of

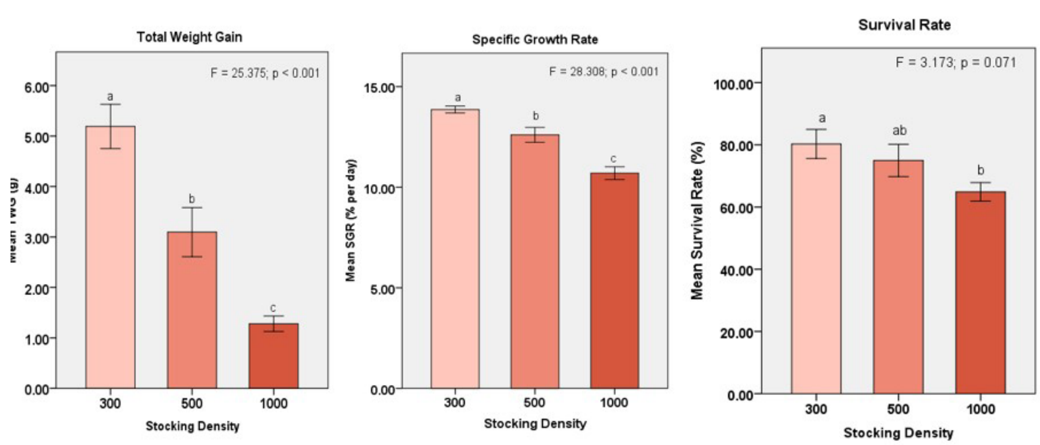

Figure 3. Mean total weight gain, specific growth rate, and survival rate of H. scabra juveniles reared at different stocking densities. Note: Different letters labeled on the bars show significant difference using the Duncan post hoc test (subset for alpha = 0.05)

Table 5. One-way ANOVA table on total weight gain, specific growth rate, and survival rate of *H. scabra* juveniles reared during different times of the year.

		Sum of Squares	df	Mean Square	*F*	*p-value*
Total weight gain	Between Groups	45.936	2	22.968	25.375	<0.001
	Within Groups	13.577	15	0.905		
	Total	59.513	17			
Specific growth rate	Between Groups	30.427	2	15.214	28.308	<0.001
	Within Groups	8.062	15	0.537		
	Total	38.489	17			
Survival rate	Between Groups	733.741	2	366.871	3.173	0.071
	Within Groups	1734.514	15	115.634		
	Total	2468.255	17			

1000 ind./cage with 64.88 ± 2.96%. The survival rate of juveniles in the different setups was significantly different (p<0.05). However, post hoc test results have shown that the survival of juveniles between 300 and 500 ind./cage did not significantly differ, and similarly, between 500 and 1000 ind./cage (p<0.05).

The findings of this study indicate that high stocking density leads to poor growth and low survival of sea cucumber juveniles. An inverse relationship between survival and stocking density were also observed during nursery culture (Seeruttun et al. 2007) and larval rearing (Asha and Diwakar 2013). Similarly, Liu et al. (2002) stressed out that overcrowding reduces available space and food, leading to reduced growth and size variability. In the small hatchery of BFAR-GMFDC, 1000 ind./cage stocking density is still being employed since space limitation and availability of floating hapa net cages are also a problem especially during batches with a high yield of early juveniles for nursery.

3.5 Hapa net cage versus rearing tank

The growth performance of juveniles reared in floating hapa net cages was better compared to those reared in indoor tanks. The mean values of total weight gain and specific growth rates were far higher in floating hapa net cages (TWG of 2.60 g and SGR of 11.67%.d^{-1}) compared to the values in rearing tanks (TWG of 0.18 g and SGR of 6.38%.d^{-1}). Results of the independent-sample t-test show that the TWG and SGR of juveniles in net cages and rearing tanks were significantly different (*p*<0.05). In contrast, rearing tanks yielded an average survival rate of 67.83%, which was higher than the yield of the floating net cages, which was 56.11%. The mean difference of the survival rates yielded by the two rearing media, however, did not differ significantly (*t* = -1.064; p = 0.313).

Rearing in floating hapa net cages yielded better growth but lower survival of juveniles compared to rearing in indoor tanks. The remarkable growth of

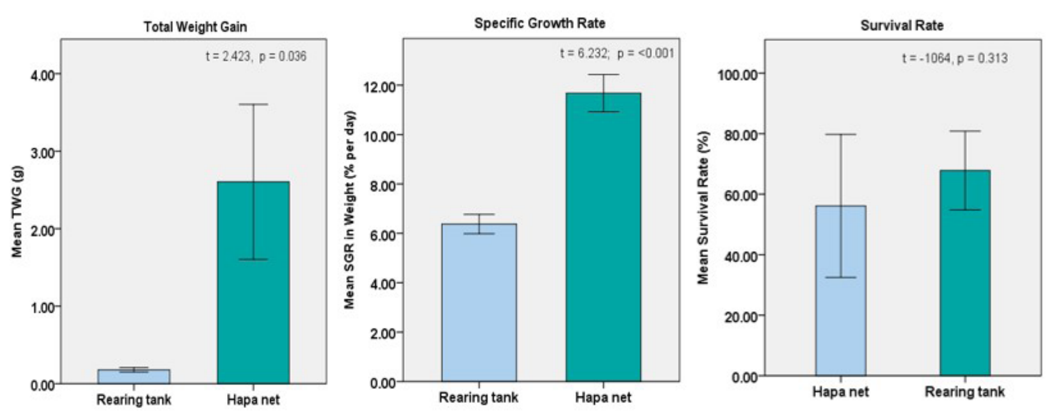

Figure 4. Total weight gain, specific growth rate, and survival rates of H. scabra juveniles reared in tanks and in floating hapa net cages. Independent sample t-test shows a significant difference between rearing tank and hapa net cages in terms of TWG and SGR (p<0.001), but not in terms of survival rate (p>0.05).

Table 6. Descriptive statistics and t-test results for growth and survival of H. scabra juveniles reared in floating hapa net cage and indoor rearing tank

	Groups		95% CI for Mean Difference	t	df	p-value
	Guiuan (Mean ± SD)	Salcedo (Mean ± SD)				
Total weight gain (g)	2.60 ± 1.00	0.18 ± 002	1.786	2.423	16	0.036
Specific growth rate (%.d-1)	11.67 ± 0.75	6.38 ± 0.39	1.384	6.232	16	< 0.001
Survival (%)	56.11 ± 9.65	67.83 ± 5.32	-8.778	-1.064	16	0.313

the juveniles in net cages could be due to the availability of diverse epibenthic microalgae, bacteria, and organic detritus on the sides of hapa nets, allowing the sea cucumber juveniles to forage on them. However, mortality in floating hapa nets cages was higher since factors such as temperature and salinity, and predation by crabs and isopods could not be controlled. Also, fine-mesh hapas can easily be clogged with fouling, and they can be torn by predatory fish and crabs (Pitt and Duy 2004). Nevertheless, this problem was addressed in this study by regular cleaning and mending of the net cages.

Poor growth of juveniles was observed in rearing tanks since the available food source was only limited to Sargassum sp. or L. papillosa crude extract mixture and the Spirulina coated on settlement plates. Moreover, the seaweed feeds formed in patches and were not evenly dispersed, which become less accessible to the slow-grazing animals. This has induced malnourishment and starvation, which eventually resulted in undersized juveniles. Mortality in indoor tanks, however, was lower compared in net cages since the conditions were more controlled. Although rearing tanks are costly and can congest a small hatchery, they are convenient for monitoring and assessment. Using them would also be advantageous during the typhoon season in the Philippines since outdoor net cages are more vulnerable to weather disturbances and strong water currents.

4. CONCLUSION

This study was conducted to optimize the methods used by BFAR-GMFDC sea cucumber hatchery in order to provide more viable seeds for reseeding and cut off expenditures all at once. Different aspects should be considered to make nursery rearing of sea cucumbers successful. The environmental conditions of the nursery system should be conducive for the growth and survival of juveniles.

The remarkable growth performance of juveniles reared in Guiuan (maximum weight gain of 6 g) was due to the better accumulation of organic detritus. However, the low survival (67%), was instigated by the presence of predatory animals, including crabs and isopods (Cymodoce sp.). Less infiltration of predators and the occurrence of diseases in Salcedo allowed the sea cucumbers to thrive better (76% survival).

Good quality and quantity of seeds can equally be produced during any period of the year since growth and survivorship of sea cucumbers did not differ significantly among different schedules. However, high precipitation and frequent weather disturbances occur at the onset of the third quarter of the year, which would cause a decline in survival of juveniles and damage in the structure of outdoor net cages. Perhaps, the best rearing season would be during the summer months.

High stocking density resulted in high mortality rates and poor growth performance of juveniles. In this study, 300 ind./cage density yielded the best growth performance (mean weight gain of 5 g) and survival (80%) of juveniles. On the other hand, juveniles stocked at 1000 ind./cage had a mean weight gain of 1.2 g and a survival rate of 65% only. Very low stocking density would not maximize the space in hapa net cages, therefore, rearing at 500 ind./cage is advised since the growth and survival did not differ significantly with that of 300 ind./cage stocking density.

Natural food such as algal biofilm and organic detritus highly contributed to the growth performance of juveniles reared in floating net cages (2.60 g total weight gain). Juveniles reared in indoor tanks had an average weight gain of 0.18 g only. Survivorship in indoor tanks was higher (67%) than in net cages (56%); however, this was not statistically significant. Nursery rearing in indoor tanks would be advantageous since they are more accessible for sampling and harvesting, and can be safeguarded from the occurrence of natural disturbances like strong currents and typhoons. To improve the growth of juveniles reared in indoor tanks, supplementation with other types of diet like algal paste and cultured diatoms should be done; however, this would augment hatchery expenses.

Ideally, nursery rearing must be done in floating hapa net cages at a stocking density of 500 ind./cage. At present, indoor tanks are not anymore utilized for the rearing of sea cucumbers at the BFAR-GMFDC hatchery, while floating net cages are being preferred. Also, sea cucumbers are still stocked at 1000 ind./cage because of space limitation and budget constraint.

This study provides information on the overall performance of nursery rearing of sea cucumbers at the BFAR-GMFDC hatchery, as well as in Eastern Samar in general, whose climate type differs from the other parts of the country. This study also affirms the methods and results of the sea cucumber research in the Philippines conducted by Juinio-Menez et al. (2012) and Gamboa et. Al (2004).

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