doi: 10.48031/msunjear.2016.04.07

Pond Based Juvenile Production of Siganids: Growth Performance of 30-Day Post Hatch *Siganus guttatus* (Bloch, 1787) at Three Stocking Densities

Michael B. Andam[1*], Gil J. Lumasag[2], Jocelyn N. Gorospe[2] and Jessie G. Gorospe[2]

[1]Davao del Norte State College
8105 New Visayas, Panabo City, Davao del Norte, Philippines

[2]Mindanao State University at Naawan
9023 Naawan, Misamis Oriental, Philippines

[*]Corresponding Author: michael_andam@ymail.com

ABSTRACT

Growth performance, survival and profit index of 30-day post hatch *Siganus guttatus* (0.08 ± 0.09 g and 1.60 ± 0.15 cm) of the same age group was evaluated for 60 days in hapa net cages (1m wide x 1m long x 1m deep) in pond based conditions. Three stocking densities were replicated three times and laid out using Completely Randomized Design (CRD). The three treatments were: 1(T1)-250 fish m^{-3}; 2 (T2)-500 fish m^{-3} and 3 (T3)-1000 fish m^{-3}. Growth performances (final weight, weight gain and specific growth rate) and survival rates of juveniles stocked in 250 fish m^{-3} was significantly higher ($P < 0.05$) than those fish stocked at 1000 fish m-3. However, growth performance and survival rates between 250 fish m^{-3} and 500 fish·m^{-3} were not significant. Feed conversion ratio (FCR) was significantly lower ($P<0.05$) in T1 than T3. However, FCR was not significant between fish stocked in T1 and T2. Net profit was higher in fish stocked in T2 compared with T1. Among the stocking densities of *S. guttatus* evaluated, 500 fish·m^{-3} appeared as the optimal stocking density based on growth, survival, FCR and profit index.

Keywords: Juvenile, *Siganus guttatus*, stocking density

INTRODUCTION

Siganus guttatus locally known as “kitong” is widely distributed in the tropical and subtropical Indo-Pacific region, and its habitats are diversified from estuarine waters to coral reefs. Recently, the farming of *S. guttatus* has received special interest due to its mariculture potential together with other high valued species like grouper, seabass, and snapper. *S. guttatus* have a great commercial potential in intensive culture because of its herbivorous to omnivorous feeding habit and feed on both filamentous green algae and formulated feeds. This species also have high consumer acceptability and commands a higher market price than milkfish. It can be monocultured or polycultured with milkfish in cages due to their ability as efficient cleaners by feeding on the macroalgae that grow on the net cages. The polyculture of this fish with milkfish is a move towards environment friendly aquaculture. Consequently, this species has been the subject of many research studies in Southeast Asian Fisheries Development Center-Aquaculture Department (SEAFDEC-AQD) and MSU at Naawan resulting in the development of technologies for captive breeding and hatchery production (Duray, 1998; Gorospe et al., 2001, 2003, 2008).

The bottleneck in the development of the aquaculture industry is the lack of reliable supply of fry for stocking in grow-out systems. Supply of fry from the wild has been dwindling over the years due to overfishing, destruction of marine habitats, and pollution of coastal waters. This massive shortfall in the supply of wild-caught fry led to the establishment of siganid hatcheries in SEAFDEC-AQD and MSU-Naawan. The demand for *S. guttatus* juveniles has increased further due to the establishment of mariculture parks and the emerging trend towards coastal aquaculture.

Nursery rearing of *S. guttatus* in MSU-Naawan Siganid Hatchery is done from day 30 up to day 90 (until complete metamorphosis to juvenile stage) before to the grow-out phase. To maintain water quality in nursery tanks, water management is made by flow through every morning. Water has to be well aerated and maintained at ambient temperature (in bigger tanks) to avoid mortality due to temperature fluctuation. Using several hatchery tanks to rear 30-days post hatch (dph) *S. guttatus* for 60 days of culture (DOC) is not cost-effective because these are better used for rearing the larvae, which have a faster turnover. With the high cost of electricity for water and aeration facilities, the feasibility of nursery rearing of *S. guttatus* in pond based condition is considered in order to cut down the production cost. Reducing the duration of nursery rearing of *S. guttatus* in the hatchery and better utilization of natural forage organisms (i.e., plankton) may be one of the possible avenues to improve juvenile production efficiency.

For the development of juvenile production of *S. guttatus* for stocking in grow-out ponds or cages, stocking density is an important factor. Stocking density is a key factor in fish farming economics because it influences growth, survival, behavior, health, water quality, feeding and production costs (Calrstein, 1995; Rahman and Marimuthu, 2010). Several studies have investigated the effect of stocking density on growth performance of various siganid species: S. canaliculatus (8 and 12 fishm^{-3}) in floating net cage (Yousif et al., 2005), *S. rivulatus* (10, 20, 30, 40 fish per 52-L) in aquarium (Saoud et al., 2007) and *S. guttatus* in cages (Destajo et al., 2010). However, no work has been done on stocking density of *S. guttatus* juveniles in nursery ponds before stocking to grow-out ponds or cages. Hence, this study was conducted to determine the effect of stocking densities on the growth performance and survival of 30 dph *S. guttatus* in pond based conditions.

MATERIALS AND METHODS

Experimental set-up and design

Nursery production of *S. guttatus* juveniles was conducted using 30 dph for 60 days from October 10-December 9, 2011. Hatchery produced 30 dph *S. guttatus* (0.08 ± 0.09 g and 1.60 ± 0.15 cm) were randomly distributed in nine hapa-net cages (1m wide x 1m long x 1m height; 0.8 m^3 water volume) with a mesh size of 1.0 to 2.0 mm (green material). After 15 days of culture (DOC) the fish were transferred in nine hapa-net cages with a bigger mesh size of 5.0 to 6.0 mm (black material, also called B-net) of the same dimensions. The nursery net cages were installed in a grow-out pond no. 1 of MSU-Naawan with an effective water volume of 0.8 m^3 for 60 days at various stocking densities. The study consisted of three treatments (T): with three replicates for each treatment. The treatments were: Treatment 1 (T1) - 250 fish m^{-3}, Treatment 2 (T2) - 500 fish m^{-3} and Treatment 3 (T3) -1000 fish m^{-3}. All treatments were randomly assigned using the Completely Randomized Design.

Collection and stocking of Siganus guttatus in pond

Hatchery-produced 30 dph *S. guttatus* were procured from the MSU Siganid Hatchery in Naawan, Misamis Oriental. Before stocking, the desired density of the fish were randomly selected and accounted during transfer from the nursery tanks to the experimental net cages. Fifty individuals of fish were measured for initial body weight and initial body length (cm) using Ohaus digital top loading balance and foot rule, respectively. Total length was measured from the tip of the snout to the farthest tip of the caudal fin. *S. guttatus* fry upon arrival were acclimatized by floating the bags for at least 20 minutes before stocking to equalize the water temperature in the plastic bags with the surrounding water. The plastic bags were opened and gradually filled with the surrounding pond water to acclimatize the fish in field conditions.

Feeds and feeding regime

The 30 dph *S. guttatus* were fed using Tateh Malaga feeds (fry booster no. 2) and then gradually weaned to fry booster no. 3. After 15 DOC the fish were fed with the combination of artificial diets (fry booster no. 3, fry mash, and shrimp flakes). Weaning from the larval diet to fry booster was done gradually a week after stocking. All the fish throughout the 60-days culture were fed five times daily (8 am, 10 am, 12nn, 2 pm, and 4 pm) at a rate of 10% of their biomass for the first month and 8 - 6% of their biomass for the rest of the culture period. Feed rate was monitored by observation for uneaten food several hours after feeding. All fish were fed slightly to excess.

The amount of feeds per day were adjusted every 15 days based on the average body weight of the S. guttatus during each sampling period.

Disclaimer: The reference to any commercial product does not constitute endorsement of that product and does not imply approval to the exclusion of other products that may be suitable.

Water management

Water exchange is very important consideration in the nursery culture of *S. guttatus* reared at various stocking densities in pond based conditions because it replaces oxygen-depleted water with oxygen –rich water culture medium. Water exchange was done during spring tide. This was done by draining 50% of the pond water and replenished with the incoming tidal water to the desired water depth. Water depth was maintained at 80 cm throughout the nursery production phase.

Physico-chemical parameters

Water quality parameters like temperature, salinity, and water transparency were monitored daily for the whole duration of the study. The readings were obtained using an alcohol-filled thermometer, refractometer (ATAGO-TANAKA S-100 model), and secchi disc (more or less 20 cm in diameter), respectively. Other water quality parameters like ammonia-nitrogen, dissolved oxygen, and pH were also monitored on a weekly basis between 5:00 and 6:00 A. M. The water samples collected every week were kept in styropore boxes brought to MSU-Naawan Chemistry Laboratory for analyses. Ammonia-nitrogen content in water was determined following the phenate method of the standard method for water and waste water examination by using the Shimadzu UV- Vis spectrophotometer set at 640 nm wavelengths (APHA, 1995). Dissolved oxygen and pH were monitored using Winkler method (Grasshoff, 1981) and a digital pH meter, respectively.

Plankton analysis

Plankton analysis was done every 15th day starting day 0 until the termination of the study. Ten liters of water were collected from different locations and depths of the pond and filtered through fine-meshed plankton net (25 µm) to obtain a 50 ml sample. The samples were preserved immediately with 5% buffered formalin in plastic bottles. Counting of plankton and identification were done using a compound microscope according to taxonomic categories at the genus level based after Hallegraeff (1988), Newell and Newell (1973), Smith and Johnson (1996) and Tomas (1997). Computation for the number of cells was done using the formula of Umaly and Cuvin (1988).

Growth performance parameters

Growth performance indices in terms of percent survival, weight gain (g), length gain (cm), specific growth rate (SGR %/day), condition factor (K %), and feed conversion ratio (FCR) were determined following the equation for weight and length gain in Rahman et al., 2009 and Yousif et al., 2005:

Survival rate (%) = 100 [(final number of fish) – (initial number of fish) / (initial number of fish)]
Weight gain (g) = (final body wt –initial body wt.)
Length gain (cm) = (final body length –initial body length)
SGR (% BW·day-1) = 100 [(ln final body wt. – ln initial body wt.) / (days)]
K (%) = 100 (final body weight, g) / (final body length, cm)^3
FCR = [feed fed (dry wt., g)] / [fish wt. gain (fresh wt., g)]

Economic analysis

Cost and return analyses were conducted to determine the profitability of the nursery culture of *S. guttatus* in pond based conditions. Cost-benefit analysis translated as return on investments (ROI) and cash payback period were determinant factors to package this technology. All expenses incurred throughout the study were recorded as a basis in calculating the production cost. ROI was determined to measure the economic profitability using the formula used in Albor and Bagcat (2006):

ROI = Net Income/Operational Cost X 100%
Cash payback period (CPP) = Total cost/average net income

Statistical analysis

All data in each parameter and treatment were expressed in terms of mean ± SD. Standard deviation (±SD) was calculated to identify the range of means. All data were analyzed using one-way analysis of variance (ANOVA) and t-test through Microsoft Office Excel™ 2007 and PAST ver. 2.17b software (Hammer et al., 2001) to test the significant differences ($P<0.05$) of the treatments. The Tukey's HSD post-hoc test was used to find out what groups showed significant differences. The statistically homogenous means were denoted by similar alphabets. Survival data were transformed to arc-sine value before conducted to statistical analysis (Gomez and Gomez, 1984).

RESULTS

Growth performance and survival

Highest growth (final weight, final length, weight gain, length increment and specific growth rate) and survival was obtained by *S. guttatus* juveniles stocked in 250 fish m^{-3} followed by 500 fish m^{-3} and 1000 fish m^{-3} (Figs. 1-2 and Table 1). However, lowest growth rates were observed in fish stocked at 1000 fish m^{-3}. The mean final weight of juveniles was significantly highest ($P<0.05$) in fish stocked in T1 (1.96 ± 0.05 g) and lowest in T3 (1.53± 0.15 g). However, the mean final weight of juveniles stocked in T1 (1.96 ± 0.05 g) and T2 (1.93 ± 0.03g) were not significantly different ($P>0.05$). The mean final length was significantly highest ($P<0.05$) in fish stocked in T1 (4.49 ± 0.10 cm) followed by T2 (4.28 ± 0.07 cm) and lowest in T3 (3.99± 0.11 cm). Weight gain was significantly highest ($P<0.05$) in fish stocked in T1 (1.88± 0.05 g) and lowest in T3 (1.45± 0.15 g). However, weight gain of juveniles stocked in T1 (1.88± 0.05 g) and T2 (1.82 ± 0.03) was not significantly different ($P>0.05$). Length increment was significantly highest ($P<0.05$) in fish stocked in T1 (2.89± 0.10 cm) followed by T2 (2.68± 0.07 cm) and lowest in T3 (2.39± 0.11cm).

Specific growth rate (SGR) was significantly highest ($P<0.05$) in fish stocked in T1 (4.88 ± 0.03 % BW day^{-1}) and lowest in T3 (4.63± 0.09% BW day-1). However, SGR of juveniles stocked in T1 (4.88 ± 0.03% BW day^{-1}) and T2 (4.85 ± 0.02% BW day^{-1}) was not significantly different ($P>0.05$). Harvested biomass increased proportionally to stocking density. Biomass was significantly highest ($P<0.05$) in fish stocked in T3 (661.62 ± 106.56 g) and lowest in T1 (336.73 ± 13.36 g). However, biomass was not significantly different ($P>0.05$) between fish stocked in T2 (611.03 ± 15.16 g) and T3 (661.62 ± 106.56 g). No significant difference was observed in the condition factor of juveniles stocked at various stocking densities. Feed conversion ratio (FCR) was significantly lowest in fish stocked in T1 (1.67± 0.06) followed by T2 (1.74 ± 0.04) and highest in T3 (2.18 ± 0.25). However, FCR of *S. guttatus* juveniles was not significantly different between fish stocked in T1 and T2 (Table 1)

Survival of 30 dph *S. guttatus* after 60 DOC was significantly highest ($P<0.05$) in fish stocked in T1 (68.83 ± 1.89%) and lowest in T3 (43.29 ± 4.92 %). However, no significant difference ($P>0.05$) was observed between the survival rates of *S. guttatus* stocked in T1 (68.83 ± 1.89%) and T2 (64.33 ± 2.13%).

Water quality and plankton monitoring

Mean values (± SD) and ranges of water quality parameters of daily and weekly samples over the 60-days culture experiment of S. guttatus in the nursery pond stocked at various densities are presented in Tables 2 and 3. There was a great variation in terms of water salinity of the nursery pond in various treatments. The salinity of the pond water was observed low from stocking to 15 days of culture (DOC); it ranged from 5 - 25 ppt with a mean of 10.60

ppt. A salinity of 5 ppt was earlier recorded after a series of heavy rains and flooding. Only after one month of culture of S. guttatus where the salinity of pond water was maintained at salinity range of 23-25 ppt. Temperature readings during 5:00-6:00 A.M, 2:00 P.M and 4:00 P.M during stocking to 15 DOC ranged from 26-320C, 30-37 0C and 29-36 0C, respectively. The mean ammonia-nitrogen contents of the nursery pond in T1, T2 and T3 were 0.108, 0.109, 0.112 ppm, respectively. Ammonia-nitrogen contents in T1, T2 and T3 showed increasing trends but the variations were not significant (Table 3). Dissolved oxygen (DO) levels was highest in T1 (4.02± 0.06; ranged from 2.80-5.09 ppm), followed by T2 (3.90± 0.09; ranged from 2.80-4.90 ppm) and T3 (3.84± 0.1O; ranged from 2.60-4.90 ppm). DO levels showed decreasing trends but the variations among treatments were not significant ($P > 0.05$). The pH value of the nursery pond in T1, T2 and T-3 were were 7.37 ± 0.02, 7.34 ± 0.01 and 7.33 ± 0.01, respectively. These pH values did not differ significantly ($P > 0.05$) but decreased from T1 to T3.

The species composition, population density and relative abundance of plankton recorded from the pond water over the 60-days culture experiment are presented in Tables 4 and 5. About eight genera of phytoplankton were identified in the nursery culture of 30 dph S. guttatus in pond based conditions. The density of phytoplankton observed showed an increasing trend from 29.87 to 80.30 cells·L^{-1}. The most dominant phytoplankton existing in the pond was *Chaetoceros sp*., *Anabaena sp*., *Rhizosolenia sp*., *Melosira sp*., and *Fragilaria sp*. The zooplankton population consisted of six genera including insects, i.e. mosquito larvae. The dominant zooplankton groups observed during the entire culture duration in terms of density were mosquito larvae, copepods and nematodes. As observed, the abundance of zooplankton did not follow the same trend with that of the phytoplankton. The density of the zooplankton declined during the termination period from 64.25 to 52.60 ind· L^{-1}.

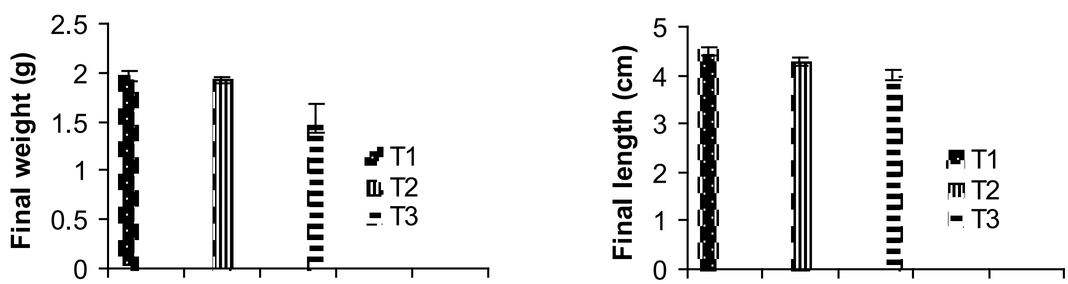

Figure 1. Growth of 30 dph *Siganus guttatus* reared for 60 days at various stocking densities in pond based conditions. A. Final weight (g) and B. Final length (cm). Vertical bars sharing the same superscript are not significantly different (P>0.05).

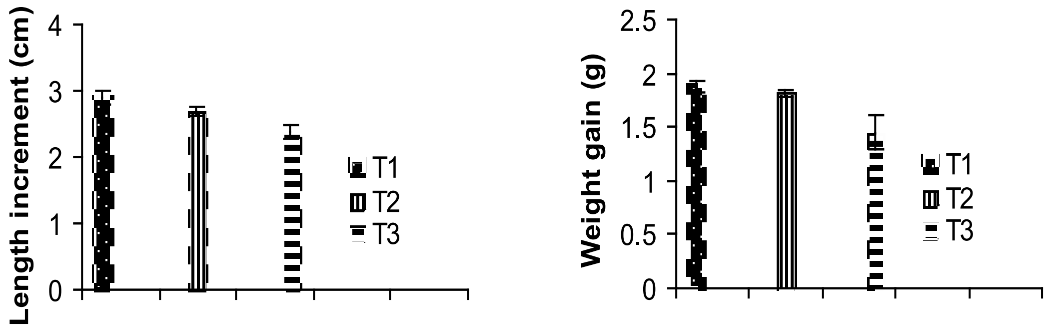

Figure 2. Growth of 30 *Siganus guttatus* in terms of A). Length increment (cm) and B). Weight gain (g) reared for 60 days at various stocking densities in pond based conditions. Vertical bars sharing the same superscript are not significantly different (P>0.05).

Table 1. Growth performance and survival of 30 dph *Siganus guttatus* reared for 60 days at various stocking densities in pond based conditions. Values are mean ±SD of three replicates.

Parameters	Treatments		
	T1 (250 fish m^{-3})	T2 (500 fish m^{-3})	T3 (1000 fish m^{-3})
Initial weight (g)	0.08 ± 0.09	0.08 ± 0.09	0.08 ± 0.09
Final weight (g)	1.96 ± 0.05^{a}	1.90 ± 0.03^{a}	1.53 ± 0.15^{b}
Weight gain (g)	1.88 ± 0.05^{a}	1.82 ± 0.03^{a}	1.45 ± 0.15^{b}
Initial length (cm)	1.6 ± 0.15	1.6 ± 0.15	1.6 ± 0.15
Final length (cm)	4.49 ± 0.10^{a}	4.28 ± 0.07^{b}	3.99 ± 0.11^{c}
Length increment (cm)	2.89 ± 0.10^{a}	2.68 ± 0.07^{b}	2.39 ± 0.11^{c}
SGR (% BW day^{-1})	4.88 ± 0.03^{a}	4.85 ± 0.02^{a}	4.63 ± 0.09^{b}
FCR	1.67 ± 0.06^{a}	1.74 ± 0.04^{a}	2.18 ± 0.25^{b}
Survival rate (%)	68.83 ± 1.89^{a}	64.33 ± 2.13^{a}	43.29 ± 4.92^{b}
Biomass (g)	336.73 ± 13.36^{a}	611.03 ± 15.16^{b}	661.62 ± 106.56^{b}
Condition factor (K)	2.16 ± 0.20^{a}	2.42 ± 0.11^{a}	2.40 ± 0.05^{a}

Values in the same row having the similar superscript are not significantly different (P > 0.05).

Table 2. Mean values (± SD) and ranges of water quality parameters of daily samples over the 60-days culture of 30 dph *Siganus guttatus* reared at various stocking densities in pond based conditions. Date at stocking: 07/10/2011

Parameters	Time of reading	Number of days			
		15th day	30th day	45th day	60th day
Salinity (ppt)	5:00-6:00 A.M	10.60± 4.53 (5-25)	23.13± 4.16 (12-25)	24.40± 0.83 (23-25)	24.47± 0.92 (23-25)
Transparency (cm)	5:00-6:00 A.M	45.80± 9.12 (27-55)	55.67± 5.30 (45-60)	48.47± 7.34 (45-67)	46.00± 2.07 (45-50)
Temperature (^{0}C)	5:00-6:00 A.M	30.47± 1.41 (26-32)	30.93± 0.26 (30-31)	30.53± 0.52 (30-31)	30.20± 0.41 (30-31)
	2:00 p.m	35.40± 2.03 (30-37)	35.53± 0.52 (35-36)	35.67± 0.62 (34-36)	35.20± 0.41 (35-36)
	4:00 p.m	34.40± 2.03 (29-36)	34.60± 0.51 (34-35)	34.93± 0.26 (34-35)	34.73± 0.46 (34-35)

Table 3. Mean values (± SD) and ranges of water quality parameters of weekly samples over the 60-days culture of 30 dph *Siganus guttatus* reared at various stocking densities in pond based conditions.

Parameters	Treatments		
	T1 (250 fish m^{-3})	T2 (500 fish m^{-3})	T3 (1000 fish m^{-3})
NH3-N (ppm)	0.108 ± 0.001a	0.109 ± 0.001a	0.112 ± 0.003a
	(0.035-0.253)	(0.045-0.271)	(0.046-0.341)
DO (ppm)	4.02 ± 0.06a	3.90 ± 0.09a	3.84 ± 0.1Oa
	(2.80-5.09)	(2.80-4.90)	(2.60-4.90)
pH	7.37 ± 0.02a	7.34 ± 0.01a	7.33 ± 0.01a
	(7-7.7)	(7-7.7)	(7-7.6)

Values in the same row having similar superscripts are not significantly different (P > 0.05).

Production and economic evaluation

Cost and returns on the nursery culture of *S. guttatus* reared for 60 days at various stocking densities in pond based conditions is presented in Table 6. Return of investment (ROI) was higher in fish stocked at 500 fish·m^{-3} (16.76 %/run or 67.04 %/yr) compared with 250 fish·m^{-3} (0.99%/run or 3.96%/yr). Net profit was also higher in fish stocked in 500 fish·m^{-3} (PhP 230.8) compared with 250 fish·m-3 (PhP 8.43). The high profitability measures of ROI value of *S. guttatus* stocked at 500 fish·m^{-3} had showed a payback period of 1.49 years. It costs PhP 4.95, PhP 4.28 and PhP 5.56 to produce a 90-day old fry for the 30 dph *S. guttatus* stocked in 250 fish·m^{-3}, 500 fish·m^{-3} and 250 fish·m^{-3}, respectively. Presently, 90-day old juveniles are sold at PhP 5.00 each.The assumptions were four runs per year since the culture period lasted for 60 days and 30 days are allotted for the disposal of the juveniles. ROI of *S. guttatus* stocked at 500 fish·m^{-3} (67.04 %) was considered a satisfactory return because the present cost of lending money (commercial bank and other lending institutions) is only 17% per annum on a quarterly basis and the net return after interest is 39.92 %. These ROI values of 30 dph *S. guttatus* stocked in 500 fish·m^{-3} are better than depositing your money in time deposit which earns an interest of only 10% per annum.

Table 4. Species composition, population density, and relative abundance of phytoplankton in the culture of 30 dph *Siganus guttatus* reared for 60 days at various stocking densities in pond.

Organisms	Day 0		15th day		30th day		45th day		60th day	
	Mean Density (cells/L)	RA (%)	Mean Density (cells/L)	RA (%)	Mean Density (cells/L)	RA (%)	Mean Density (cells/L)	RA (%)	Mean Density (cells/L)	RA (%)
Anabaena sp.	4.83± 0.08	16.18± 0.25	7.53± 0.21	24.21± 0.68	11.38± 0.18	20.7± 0.32	4.35± 0.10	35.8± 0.83	18.58± 0.08	23.14± 0.10
Chaetoceros sp.	6.00± 0.25	20.09± 0.84	7.07± 0.18	22.73± 0.57	10.37± 0.13	18.85± 0.23	4.07± 0.10	33.47± 0.86	16.72± 0.08	20.82± 0.10
Fragilaria sp.	2.52± 0.23	8.43± 0.76	3.37± 0.10	10.83± 0.34	4.53± 0.25	8.24± 0.46	1.65± 0.15	13.58± 1.23	8.88± 0.08	11.06± 0.10
Melosira sp.	4.15± 0.13	13.89± 0.20	5.15± 0.10	16.56± 0.33	7.62± 0.16	13.85± 0.29	0.00	0.00	8.62± 0.10	10.73± 0.12
Navicula sp.	2.25± 0.18	7.53± 0.60	0.00	0.00	5.52± 0.13	10.03± 0.23	0.00	0.00	0.00	0.00
Nitzschia sp.	1.82± 0.08	6.09± 0.25	2.80± 0.15	9.01± 0.49	3.72± 0.23	6.76± 0.41	0.00	0.00	0.00	0.00

Table 5. Species composition, population density, and relative abundance of zooplankton and associates in the culture of 30 *Siganus guttatus* reared for 60 days at various stocking densities in pond.

Organisms	Day 0		15th day		30th day		45th day		60th day	
	Mean Density (cells/L)	RA (%)	Mean Density (cells/L)	RA (%)	Mean Density (cells/L)	RA (%)	Mean Density (cells/L)	RA (%)	Mean Density (cells/L)	RA (%)
Cladocerans	3.58± 0.08	5.58± 0.12	5.6± 0.1	6.38± 0.12	2.32± 0.16	4.13± 0.29	7.18± 0.08	7.09± 0.08	0.00	0.00
Copepods	18.37± 0.32	28.59± 0.50	25.15± 0.13	28.64± 0.15	12.17± 0.08	21.69± 0.14	30.18± 0.08	29.79± 0.08	11.62± 0.10	22.08± 0.20
Nematodes	15.12± 0.13	23.53± 0.20	22.18± 0.16	25.26± 0.19	11.52± 0.13	20.54± 0.23	25.35± 0.13	25.02± 0.13	10.18± 0.08	19.36± 0.15
Ostracods	1.58± 0.08	2.46± 0.12	0.00	0.00	0.00	0.00	2.18± 0.08	2.15± 0.08	0.00	0.00
Mosquito larvae	20.5± 0.50	31.91± 0.78	24.5± 0.5	27.9± 0.57	25.5± 0.50	45.46± 0.89	28.18± 0.16	27.82± 0.16	26.15± 0.13	49.71± 0.25
Rotifers	5.1± 0.10	7.94± 0.16	10.38± 0.13	11.82± 0.15	4.58± 0.08	8.17± 0.14	8.25± 0.05	8.14± 0.05	4.65± 0.13	8.84± 0.25
TOTAL	64.25	100	87.81	100	56.09	100	101.32	100	52.6	100

DISCUSSION

Growth performance and survival

Growth in terms of final weight, weight gain and specific growth rate of *S. guttatus* juveniles stocked in 250 fish m^{-3} was significantly higher ($P < 0.05$) than those fish stocked at 1000 fish m^{-3} in pond based conditions. The lowest growth rates of juveniles were observed in fish stocked at 1000 fish·m^{-3} although same food was applied at an equal ratio in all treatments. Probably, the causes of growth inhibition of *S. guttatus* stocked at 1000 fish m^{-3} may be due to overcrowding which resulted to strong competition for food and space. Fish live and move in a three-dimensional medium that is vital for survival and expression of their full range of natural behaviors (FSBI, 2002; Conte, 2004; Lembo and Zupa, 2010). Furthermore, among fish, there are many interspecific differences in space needs and tolerance of stocking density. In general, high density conditions may increase swimming activity and behavioral interactions between fish, leading to a rise in energetic expenditures up to levels that could be detrimental for physiological processes (Lembo and Zupa, 2010). The results of the study coincides with the findings of Destajo et al., 2010 that low stocking densities for siganid culture provided better growth for the fish than at higher stocking densities.

Most of the studies on stocking density of various cultured fish species showed that high stocking densities have undesirable impact on the health and welfare of fish. In particular, higher stocking densities beyond the optimum levels, may lead to reduction of growth rate, increase of feed conversion ratio, lowering of survival rate and poor body condition (Ellis et al., 2002; Yousif, 2002). Rearing of fish at high stocking densities may impair growth and reduce immune competence due to factors such as social interaction and the deterioration of water quality, which affect feed intake and conversion efficiency (Ellis et al., 2002). No significant difference was observed in the condition factor of juveniles stocked at various stocking densities.

The higher growth rates and no significant effects of stocking densities on the condition factors of S. guttatus reared for 60 days at various stocking density in pond based conditions was probably due to the feed offered which is rich in protein and lipid. In addition, this was possibly due to the availability of the natural foods (plankton) present in the pond. The higher condition factor values of *S. guttatus* were also probably due to its wider body and shorter body length. The condition factor obtained in this study was above 1.0, it showed that the feeds were properly utilized for better growth and sound health. Weight–length relationships, such as the condition factor used in this study are used for various reasons, such as comparing a population's 'well-being' among the same fish species in nature (Anderson and Neumann, 1996) or evaluating the physiological health of fish.

Apart from a varied response to increased stocking density in *S. guttatus*, the effect of deteriorating water quality associated with the higher density might be one of the reasons

Table 6. Cost and returns on the nursery culture of *Siganus guttatus* reared for 60 days at various stocking densities in pond based conditions.
Legend: CPP- Cash Payback Period; ROI- Return on Investment

Items	Treatments		
	T1 (250 fish m^{-3})	T2 (500 fish m^{-3})	T3 (1000 fish m^{-3})
A. Production and sales			
Stocking density m^{-3}	250	500	1000
Harvest size (g)	2.74	2.67	2.36
Production volume (pcs)	172.08	321.65	432.90
Selling price (PhP)	5	5	5
Gross sales/run (PhP)	860.38	1,608.25	2,164.50
B. Variable cost (PhP)			
Postlarvae	500	1000	2,000
Feeds			
Artemia	9.38	18.75	37.50
Artificial diet	18.49	18.49	34.88
Total variable cost (PhP)	527.868	1,053.63	2,084.01
C. Fixed cost (PhP)			
Nursery net (B-Net)	288.33	288.33	288.33
Depreciation	2.67	2.67	2.67
Nursery net (Fine mesh net)	32.78	32.78	32.78
Depreciation	0.30	0.30	0.30
Total fixed cost (PhP)	324.08	323.78	323.78
Total production Cost (PhP)	851.95	1377	2408
Net Profit (PhP)	8.43	230.8	-243.3
CPP (Years)	25.27	1.49	-2.47
ROI/run (%)	0.99	16.76	-10.1
ROI/yr (%)	3.96	67.04	-40.42
Production cost/fry (PhP)	4.95	4.28	5.56

Assumptions:

1. Cost of post larvae for 30 dph is PhP 2.00 and sold at PhP 5.00/piece; for 45 dph is PhP 2.50 and sold at PhP 7.00/piece
2. Estimated life span of nursery net (B-net and fine mesh net) is 3 years
3. Depreciation cost of one B-net cage and fine mesh net cage are PhP 10.68/year and PhP 1.21/year, respectively.
4. Prices reflected are as of the year 2011
5. CPP is computed at four runs per year
6. Excluding construction of nursery pond

for sub-optimal growth performance. Fish condition can be extremely important to fisheries managers. Plump fish may be indicators of favorable environmental conditions (e.g., habitat conditions, ample prey availability), whereas thin fish may indicate less favorable environmental conditions (Blackwell, et al., 2000). FCR was significantly lowest in fish stocked in 250 fish m^{-3} followed by 500 fish·m^{-3} and highest in 1000 fish m^{-3}. However, FCR of *S. guttatus* juveniles was not significantly different between fish stocked in T1 and T2. The FCR of the study are lower than the FCR values reported by many researchers (Rahman et al., 2009; Rahman and Marimuthu, 2010). The causes might be smaller ration size, higher digestibility and proper utilization of feed. De Silva and Davy, 1992 stated that digestibility plays an important role in lowering the FCR value by efficient utilization of food. However, the lower FCR value in this study indicated better food utilization efficiency, despite the values increased with increasing stocking densities. Lower levels of stocking densities showed better FCR, an indication that *S. guttatus* consume more feed when their stocking density was lower. These results showed that the ability of fish to convert feed into flesh decreased as the stocking density increased. The relatively low FCR values obtained are not surprising given that the feed administered to the experimental fish was high in crude protein plus the additional contribution of the natural food organisms available in the nursery pond. Specific growth rates decreased with increasing stocking density of the fish. The specific growth rate is observed to vary depending on the size of fish; smaller fish grow faster than larger ones (Sumpter, 1992). Growth rate is considered a trait of great economic importance for all species used in aquaculture. Rapid growth speeds up the turnover of production (Gjerde, 1986).

Survival of *S. guttatus* was significantly highest ($P<0.05$) in T1 and lowest in T3. However, no significant difference ($P>0.05$) was observed between the survival rates of *S. guttatus* stocked in T1 and T2. Low survival rates of *S. guttatus* at the highest stocking density, 1000 fish m^{-3} could be due to high competition for food and space in hapa net cages.

Environmental parameters exert a significant influence on the maintenance of a healthy aquatic environment and production of natural food organisms. Feed efficiency, feed consumption and growth of fish are normally influenced by a few environmental factors. The incidence of mortalities was noted in all treatments during the first week of culture of the 30 dph *S. guttatus* of various stocking densities. The possible cause was due to overnight heavy rain causing high turbidity, low salinity (5-7 ppt) and water temperature (26^0C) level of the surface water which was very critical to the fish. It was observed that the experimental animals had good response to the feeds offered when the temperatures were at the level of 28^0C to 32^0C. However, at the onset of the rainy periods there was a drastic reduction in water temperatures which probably led to the subsequent non-consumption of feeds. Afternoon water temperatures observed were high with the range of 34^0C to 37^0C. This range of temperature was higher compared to the optimum range of temperature required for many warm water fishes which is 24-30^0C (Adhikari, 2003).

Farmed fish are exposed to a range of potentially stressful conditions (e.g. water quality such as low oxygen, high temperature and high turbidity), often in combination with high fish stocking densities, thus affecting the profitability of the aquaculture industry. The average values of transparency in the present study showed weekly variations and such variations may be caused by a number of factors, e.g., time of the day, season, and weather. Highest transparency depth was also observed in the study, which might be due to the reduction of the plankton population density by higher stocking biomass of fish. Dissolved oxygen level was low in hapa net cages stocked with a higher density of fish compared to hapa net cages with low stocking density, might be due to the higher consumption rate of oxygen by the higher density of fish and other aquatic organisms. Dissolved oxygen level (2.60 - 2.80 ppm) was low in nursery ponds compared to nursery tank. Dissolved oxygen is the single environmental parameter that exerts a tremendous effect on growth and production through its direct effect on feed consumption and metabolism and its indirect effect on environmental conditions. It also affects the solubility of many nutrients.

Low levels of dissolved oxygen can cause changes in oxidation state of a substance from the oxidized to the reduced form. This is because under anaerobic conditions, these substances function as electron acceptors in place of oxygen. Lack of dissolved oxygen can be directly harmful to fish or cause substantial increase in the level of toxic metabolites (Chiu, 1988). DO levels <3 ppm are stressful to most aquatic organisms while DO concentration of <2 ppm could no longer support fish life. DO levels of 5-6 ppm are required for growth and activity of most aquatic organisms. Dissolved oxygen concentration of the 30 dph *S. guttatus* in nursery tanks were in the range of 6.01 to 7.01 ppm. This range is above the minimum 5 mgL^{-1} DO concentration for fishery water that is fit for growth and propagation of fish (Chiu, 1988; Adhikari, 2003).

The water pH observed was within the range of good water quality for rearing of fry/ fingerlings in nursery pond and nursery tank. Water pH is an important parameter because it affects the metabolism and other physiological processes of fish. A pH 6.8-8.7 is optimum for fish growth and production (Chiu, 1988). The level of ammonia-nitrogen recorded from the nursery pond was lower than that of the nursery tank. Normally, pond water does not contain high levels of ammonia because of the mechanisms involved in the accumulation and trapping of bound ammonia in the pond sediments and the rapid uptake of ammonia by photosynthetic cyanobacterial surface bloom which is continuously renewed by periodic daily partial photooxidation (Shilo and Rimon, 1982 as cited in Chiu, 1988). Healthy phytoplankton populations also remove ammonia from water (Adhikari, 2003). However, the present level of ammonia-nitrogen content in the experimental pond and nursery tank was not lethal to the fish (Kohinoor et al., 2001). Fish are very sensitive to unionized ammonia (NH_3) and the optimum range is 0.02-0.05 mg/L in the pond water (Adhikari, 2003). Ammonia is toxic to fish if allowed to accumulate in fish production systems. When ammonia accumulates to toxic levels, fish cannot extract energy from feed efficiently. If the ammonia concentration gets high enough, the fish will become lethargic and eventually fall into a coma and die. In properly managed fish ponds, ammonia seldom accumulates to lethal concentrations. However, ammonia can have so-called "sublethal" effects—such as reduced growth, poor feed conversion, and reduced disease resistance—at concentrations that are lower than lethal concentrations (Hargreaves, 2004).

CONCLUSION

Overall, the highest growth (final weight, weight gain and specific growth rate) and survival rates of *S. guttatus* juveniles were obtained in fish stocked in 250 fish m^{-3} than those fish stocked in 1000 fish·m^{-3} in pond based conditions. However, growth performance and survival of juveniles stocked in 250 fish m^{-3} and 500 fish m^{-3} were not significantly different (P>0.05). FCR of *S. guttatus* was significantly lowest in fish stocked in 250 fish m^{-3} and highest in 1000 fish m^{-3}. However, FCR of *S. guttatus* juveniles was not significantly different between fish stocked in 250 fish m^{-3} and 500 fish m^{-3}. Thus, results of the study conclude that among the stocking densities of S. *guttatus* evaluated, 500 fish m^{-3} appeared as the optimal stocking density in the nursery pond based on growth, survival, and FCR. Furthermore, results of the study also conclude that nursery culture of 30 dph *S. guttatus* in pond based conditions beyond 500 fish m^{-3} may lead to reduction of growth rate, increase of feed conversion ratio and reduction of survival rates. Higher profit index of the fish stocked at 500 fish m^{-3} over 250 fish m^{-3} implies that 500 fish m^{-3} may be better in economic terms than 250 fish m^{-3}. This is also reflected in the lack of significant difference (P > 0.05) in the FCR and SGR between fish stocked in 250 fish m^{-3} and 500 fish m^{-3}. It is therefore apparent that biological and economic benefit will be achieved in nursery culture of 30 dph *S. guttatus* when stocked at 500 fish m^{-3}.

LITERATURE CITED

Adhikari, S. 2003. Fertilization, soil and water quality management in small-scale ponds. Part II – Soil and water quality management. Aquaculture Asia. January-March 2003 (Vol. VIII No. 1).

Albor, G. C. and C. D. Bagcat. 2006. Culture of GET EXCEL Tilapia in different location in Region 10. DA-BFAR 10, Macabalan, Cagayan de Oro City. In: Proceedings of the 11th Annual Zonal RD&E Review and S&T Planning Workshop. Misamis Occidental Aquamarine Park, Sinacaban, Misamis Occidental. December 11, 2006. Mindanao State University at Naawan 9023 Naawan, Misamis Oriental.pp 203-217.

Anderson, R. O and R. M. Neumann. 1996 Length, weight, and associated structural indices. In: Murphy BR,Willis DW (eds) Fisheries techniques, 2nd edn. American Fisheries Society, Bethesda, pp 447–481.

Carlstein, M. 1995. Growth and survival of European grayling reared at different stocking densities. Aquaculture International Volume 3, Number 3, 260-264.

Chiu, Y. N. 1988. Water quality management for intensive prawn ponds. In. Y.N. Chiu, L.M. Santos and R.O. Juliano (eds) Technical considerations for the management and operation of intensive prawn farms. U.P. Aquaculture Society, Iloilo City, Philippines. pp 102-128.

Conte, F. S. 2004. Stress and the welfare of cultured fish. Appl. Anim. Behav. Sci. 86, 205–223.

De Silva, S.S. and F.B. Davy, 1992. Fish nutrition research for semi-intensive culture system in Asia. Asian Fisheries Science, 5: 129-144.

Destajo, W. H., M. I. Tumanda, R. D. Gaid, D. M. Dagapioso and M. B. Quiñones. 2010. Culture of golden rabbitfish, *Siganus guttatus* in fish cages. Mindanao State University at Naawan. National conference and workshop on the biology and culture of siganids held on July 23-24, 2010 at the Function House, MSU-Naawan Campus, Naawan, Misamis Oriental.

Duray, M. N. 1998. Biology and Culture of Siganids. SEAFDEC Aquaculture Department, Tigbauan, Iloilo City, Philippines. 53 pp.

Ellis, T., B. North, A. P. Scott, N. R. Bromage, M. Porter and D. Gadd. 2002. The relationships between stocking density and welfare in farmed rainbow trout. Journal of Fish Biology, 61: 493-531.

FSBI (Fisheries Society of the British Isles). 2002. Fish Welfare. Breifing Report 2. Granta Information systems. http://www.le.ac.uk/biology/fsbi/welfare.pdf.

Gjerde, B. 1986. Growth and reproduction in fish and shellfish. Aquaculture, 57: 37-55.

Gomez, K. A.,and A. A. Gomez. 1984. Statistical procedures for agricultural research. IRRI, Los Baños, Laguna, Philippines.

Gorospe J. N., E. G.Tubio, M. B. Quiñones, M. M. Ologuin and J. G. Gorospe. 2008. Age and reproductive potential of domesticated Siganus guttatus (Bloch) Breeders. Proceedings of the 13th Annual Zonal RD&E Review and S&T Planning Workshop. Kansilad Beach Resort Cansilad, Ganayon, Lianga, Surigao del Sur 26-28 November 2008. Mindanao State University at Naawan 9023 Naawan, Misamis Oriental.pp 52-60.

Gorospe, J. N. M. I. Tumanda, W. H. Destajo, E. Y. Adan, M. B. Quinones, M. M. Ologuin, E. G. Tubio, A. J. Laurden, R. L. Roa, R. D. Gaid and D. D. Gonzales. 2003. Reproductive performance of siganid fed broodstock diets. Proceedings of the 8th Annual Zonal RD&E Review and S&T Planning Workshop.Naawan Beach Resort. November 12-13, 2003. Mindanao State University at Naawan 9023 Naawan, Misamis Oriental.pp 212-228.

Gorospe, J. N. M. I.Tumanda, W. H. Destajo, E. Y. Adan, M. B. Quinones, M. M. Ologuin, E. G. Tubio, A. J. Laurden, R. L. Roa, R. D. Gaid, D. D. Gonzales and E. M. Arriesgado. 2001. Refinement of siganid hatchery technology in Mindanao. Proceedings of the 6th Annual Zonal R&D Review and S&T Planning Workshop.pp 118-120.

Grasshoff, K. 1981. In: Marine Electrochemistry, Whitfield, M., and Jagner, D. (Ed). John Wiley and Sons. pp. 327-420.

Hallegraeff, G. M. 1988. Plankton a microscopic world. E.J. Brill Pub. Com. CSIRO Australia. 105 pp.

Hammer, Ø., D. A. T, Harper and P. D. Ryan. 2001. PAST: Paleontological statistics software package for education and data analysis. Palaeontologia Electronica 4(1): 9pp. http://palaeo-electronica.org/2001_1/past/issue1_01.htm.

Hargreaves J. A and C. S. Tucker. 2004. Managing Ammonia in Fish Ponds. SRAC Publication No. 4603.

Kohinoor, A. H. M., M. A. Wahab, M. L. Islam and S. H. Thilsted. 2001. Culture potentials of mola (*Amblypharyngodon mola*), chela (*Chela cachius*) and punti (*Puntius sophore*) under monoculture system. Bangladesh Journal of Fisheries Research, 5(2): 123-134.

Lembo, P. and W. Zupa. 2010. Fish welfare - a key issue for organic system standards. In: Szeremeta, A., L. Winkler, F. Blake, and P.Lembo (eds). International Federation of Organic Agriculture Movements EU Group (IFOAM EU Group): “Organic Aquaculture. EU Regulations (EC) 834/2007, (EC) 889/2008, (EC) 710/2009. BACKGROUND, ASSESSMENT, INTERPRETATION. Rue du Commerce 124, 1000 Brussels, Belgium. pp. 28-31.

Newell, G. E. and R. C. Newell. 1973. Marine Plankton. A Practical Guide. Hutchinson Educational, LTD., London. 244 pp.

Rahman, M. A. and K. Marimuthu. 2010. Effect of different stocking density on growth, survival and production of endangered native fish climbing perch (*Anabas testudineus*, Bloch) fingerlings in nursery ponds: Adv. Environ. Biol., C (): CC-CC, 2010.

Rahman, M. A., M. Zaher and K. M. Azimuddin. 2009. Development of fingerling production techniques in nursery ponds for the critically endangered reba carp, *Cirrhinus ariza* (Hamilton, 1807). Turkish Journal of Fisheries and Aquatic Sciences 9: 165-172 (2009).

Saoud, I. P., J. Ghanawi and N. Lebbos. 2007. Effects of stocking density on the survival, growth, size variation and condition index of juvenile rabbitfish *Siganus rivulatus*. Aquacult Int DOI 10.1007/s10499-007-9129-7.

Smith, D. L. and K. B. Johnson. 1996. A guide to marine coastal plankton and marine invertebrate larvae. 2nd ed. Kendall Hunt Pub. Com. USA. pp 1-221.

Sumpter, J. P. 1992. Control of growth of rainbow trout (*Oncorhynchus mykiss*). Aquaculture, 92: 299-320.

Umali, R. C. and M. A. Cuvin. 1988. Limnology: Laboratory and field guide physico-chemical factors, biological factors. Phil. Nat'l. Bookstore. 322 p.

Yousif, O. M. 2002. The effects of stocking density, water exchange rate, feeding frequency and grading on size hierarchy development in juvenile Nile tilapia, *Oreochromis niloticus* L.. Emir. J. Agric. Sci. 14: 45-53.

Yousif, O. M., K. Kumar and A. A. Ali. 2005. Growth performance, feed utilization, survival and body composition of rabbitfish Siganus canaliculatus raised at two different stocking densities in sea net cages. Fish and Shrimp Farming Project – Abu Al Abyad, Abu Dhabi, P.O. Box 372, United Arab Emirates Emir. J. Agric. Sci. 2005. 17 (2): 14-22 http://www.cfa.uaeu.ac.ae/Research/EJAS.htm.