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Growth and Survival Rates and Feed Utilization of Orange-spotted grouper *Epinephelus coioides* Cultured at Different Stocking Densities in Floating Net Cage

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ABSTRACT

Epinephelus coioides, commonly known as orange-spotted grouper, has potential aquaculture prospects due to its scarcity in the wild and marketability in semi-tropical and tropical regions. A floating net cage system has been demonstrated to be a technically and commercially feasible method of raising fish, allowing for a much higher stocked density of fish. In this study, orange-spotted grouper (*E. coioides*) was cultivated in a floating net cage fed with trash fish (*Decapterus* sp. and *Sardinella* sp.) to determine the effect of stocking density on survival rate (SR) and specific growth rate (SGR). In addition, feed conversion ratio (FCR) and feed intake (FI) were also investigated. Three stocking densities: 20 fish/m^3, 30 fish/m^3, and 40 fish/m^3, were used in the study. Results showed that *E. coioides* cultured at a stocking density of 20 fish/m^3 in a floating net cage gained the highest SGR and SR significantly (p<0.05). FI was significantly lesser (p<0.05) at a stocking density of 30 fish/m^3, while FCR was significantly lower (p<0.05) at a stocking density of 40 fish/m^3. Thus, this study suggests that a smaller stocking density of 20 fish/m^3 is more effective to be used in the culture of grouper *E. coioides* in a floating net cage.

KEYWORDS: *Epinephelus coioides*, floating net cage, growth, orange-spotted grouper, stocking density

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1. Introduction

Aquaculture is the fastest-growing subsector of the food industry, surpassing terrestrial meat production and natural capture fisheries (Aypa and Baconguis, 2000; Tacon, 2001; BFAR, 2019; Tahiluddin and Terzi, 2021a). Global aquaculture production of 114.5 million tons of live fish in 2018 resulted in a total farm gate sale value of USD 263.6 billion. Nearly 46 percent of the fish production was intended to be consumed by humans, while 52 percent was used to feed wildlife (FAO, 2020). As the world population continues to increase, the demand for seafood products as a protein source also rises (Merino et al., 2012; Tahiluddin and Terzi, 2021b). In many developing nations, including Africa and Asia, aquaculture has been introduced to help people overcome poverty and improve living standards (Edwards, 2000). The production of fish in natural waters and aquaculture is becoming increasingly important as a relatively cheap source of protein for humans and livestock (Coche et al., 1994; Khalil and Polling, 1997; Bichi and Yelwa, 2010; Komatsu and Kitanishi, 2015). Aquaculture not only supplies food for immediate consumption but also provides large numbers of jobs and economic gains (Tahiluddin and Kadak, 2022). In Southeast Asian countries, among the important cultured species that supports economic development is the grouper (Pierre et al., 2008). In the Philippines, the grouper is considered to be a highly prized and good-tasting fish (Kohno et al., 1988; Baliao et al., 2000). Thus, this species of finfish offers a lot of potential for aquaculture.

Throughout Southeast Asia, the grouper *Epinephelus* spp., locally known as *lapu-lapu* or *inid* in the Philippines, has been cultured for decades in ponds and net cages, and trawlers and purse seiners traditionally fed grouper with trash fish (Baliao et al., 2000; Hseu, 2002; Pomeroy, 2002). Bamboo fish traps, gill-net and hook and line are common methods of catching groupers by small-scale fishermen (Kohno et al., 1988). As one of the most valuable food fish in the Philippines, groupers make up 2% of the total seafood catch, making aquaculture of this species of finfish very promising (Kohno et al., 1988; Baliao et al., 2000). In addition, it is expected that in the near future, the grouper's export price will increase as demand for the product in international markets increases, particularly in Japan, Hongkong and Singapore (Baliao et al., 2000). Therefore, grouper culture could provide the country with another source of revenue.

The advantage of growing fish in a floating net cage is that they can be stocked much more densely than in other types of fish farming (Cache, 1976). Nonetheless, the degree to which grouper eggs hatch depends on the stocking density (Fukuhara, 1989). The flow of water current in coastal waters or rivers allows for high stocking densities of fish in floating net cages due to the fact that it supplies adequate amounts of dissolved oxygen, removes metabolic wastes from fish, and reduces the effects of overcrowding (Teng and Chua, 1978). To ensure optimal stocking density, floating net cages are stocked based on the species, size and weight of fish initially stocked, location, cage shape and size (Teng and Chua, 1978). In net cages, varying optimum stocking densities for different economically fish species have been reported (Bardach et al., 1972; Howard, 1974; Fujiya, 1976). Previous studies for the past decades have been carried out to determine the optimum stocking densities of orange-spotted grouper *E. coioides* in the recirculating system (Samad et al., 2014), estuary grouper *E. salmoides* in a floating net cage (Teng and Chua, 1978; Chua and Teng, 1979), tiger grouper *E. fuscoguttatus* in a flow-through system (Salari et al., 2012), and hybrid grouper ♂ *E. lanceolatus x* ♀ *E. fuscoguttatus* in recirculating aquaculture systems (Shao et al., 2019). The purpose of this study was to determine the different stocking densities, i. e. 20, 30, and 40 fish/m^3 of orange-spotted grouper *E. coioides* in floating net cage cultured along the Bongao channel in Tawi-Tawi, Philippines.

2. Material and Methods

Study site and Duration

The study was carried out along the Bongao Channel, Tawi-Tawi, Philippines (05º02' 09.7" N, 119º44' 54.5" E) for a duration of 60 days.

Experimental fish

The orange-spotted grouper (*E. coioides*) used in the study was obtained from Multi-species Hatchery, Lato-Lato, Bongao, Tawi-Tawi with an average weight of 12.17 ± 0.81g.

Experimental Design

This experiment utilized net cages that were suspended from a wooden frame. Each net cage is 1 x 1 x 1 m in size and is made of polyethylene netting with a mesh size of about 0.5 cm. A total of 12 cages were suspended in the water. The fish were stocked randomly using three stocking densities: 20, 30 and 40 fish per m^3 represented here as T_1, T_2 and T_3, respectively. Each treatment had four replications. The water parameters, like salinity and temperature, were 33 – 35 ‰ and 26 – 29 ˚C, respectively. Water can freely exchange between cages and the ocean due to tidal currents.

Feeding

Trash fish, such as scads (*Decapterus* sp.) and sardines (*Sardinella* sp.), was chopped into tiny pieces and fed to the fish. Feeding was done twice a day in the afternoon with 10% of the average body weight (Galzote and Abrera, 2007).

Sampling

Sampling was conducted every 15 days during the culture period to determine the survival and growth rates of orange-spotted grouper *E. coioides* cultured in a floating net cage. The survival rate, specific growth rate (SGR), and feed utilization were computed using the following formula (Kader et al., 2017):

$$\text{Survival rate (\%)} = \frac{\text{Final number of stocks}}{\text{Initial number of stocks}} \times 100$$

$$\text{WG (g)} = \text{ABWf} - \text{ABWi}$$

$$\text{SGR (\% Day)} = \frac{\ln(\text{ABWf}) - \ln \text{ABWi}}{\text{DOC}} \times 100$$

Where: WG = weight gain
ABWf = average body weight final
ABWi = average body weight initial
DOC = days of culture

$$\text{FCR} = \frac{\text{FI}}{\text{WG}}$$

Where: FCR = feed conversion ratio
FI = feed intake
WG = weight gain

Statistical analysis

IBM SPSS version 20 was used to analyze the data at a significance level of 0.05. The collected data were presented as the mean ± standard error of the mean (SEM). One-way analysis of variance (ANOVA) was performed on the data to identify significant differences in the different treatments in terms of growth rate, survival rate, and feed utilization. Duncan's Post-Hoc Test was used to rank the mean

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3. Results

Table 1 shows the growth rate, survival rate, and feed utilization of *E. coioides* cultured at different stocking densities in a floating net cage for 60 days. The average final weights of individual fish in T_1 (20 fish/m^3), T_2 (30 fish/m^3) and T_3 (40 fish/m^3) were 38.59 ± 0.95 g, 24.33 ± 0.53 g and 17.26 ± 0.52 g, respectively. Results revealed that T_1 was significantly higher than T_2 and T_3. The mean gain weight of fish in T_1 (25.87 ± 0.95 g) was significantly greater than T_2 (13.26 ± 0.53 g) and T_3 (4.56 ± 0.51 g). SGR of T_1, T_2 and T_3 were 1.85 ± 0.04 % day^{-1}, 1.31 ± 0.04 % day^{-1} and 0.51 ± 0.05 % day^{-1}, respectively, indicating that T_1 was significantly higher ($p<0.05$) among treatments. In addition, survival rates of T_1, T_2 and T_3 were 92.50 ± 1.44 %, 89.17 ± 2.10 % and 83.75 ± 2.17 %, respectively and analysis showed T_1 was significantly higher ($p<0.05$) than T_3 at the end of the culture period, but not significant with T_2. The feed intake (FI) of T_2 (37.89 ± 0.88) was statistically lower ($p<0.05$) than T_1 (45.72 ±1.45) and T_3 (56.17 ± 0.57). Moreover, the feed conversion ratio (FCR) of T_1, T_2, and T_3 were 0.57 ± 0.02, 0.35 ± 0.01, and 0.08 ± 0.01, respectively, where T_3 was significantly lower ($p<0.05$) among treatments.

Table 1. Growth rate, survival rate, and feed utilization of *E. coioides* cultured at different stocking densities in a floating net cage.

Treatment	IW (g)	FW (g)	WG (g)	SGR (%)	SV (%)	FI	FCR
T_1 (20 fish/m^3)	12.73 ± 0.01	38.59 ± 0.95^a	25.87 ± 0.95^a	1.85 ± 0.04^a	92.5 ± 1.44^a	45.72 ±1.45^b	0.57 ± 0.02^a
T_2 (30 fish/m^3)	11.07 ± 0.01	24.33 ± 0.53^b	13.26 ± 0.53^b	1.31 ± 0.04^b	89.17 ± 2.10^{ab}	37.89 ± 0.88^c	0.35 ± 0.01^b
T_3 (40 fish/m^3)	12.70 ± 0.01	17.26 ± 0.52^c	4.56 ± 0.51^c	0.51 ± 0.05^c	83.75 ± 2.17^{bc}	56.17 ± 0.57^a	0.08 ± 0.01^c

IW: initial weight; FW: final weight; WG: weight gain; SGR: specific growth rate; SV: survival rate; FI: feed intake; FCR: food conversion ratio. Rows with different letters are significantly different ($p<0.05$).

4. Discussion

In aquaculture, the production and growth of cultured fish are primarily dependent on population density (Teng and Chua, 1978; Chua and Teng, 1979). Culturing fish using greater stocking density has resulted in reduced growth and survival rates as well as an increased food conversion ratio (Powell, 1972). Additionally, the higher the stocking densities coupled with unsuitable feeding, the greater the size variation (Hseu, 2002). In the present study, a stocking density of 20 fish/m^3 fish gained the highest growth rate compared to fish cultured at 30 and 40 fish/m^3 stocking densities. The survival rate was better in 20 and 30 fish/m^3 cultured in floating net cages. In addition, the feed intake was lowest in 30 fish/m^3, and the feed conversion ratio was lowest in 40 fish/m^3. However, different results were obtained when the same species *E. coioides* cultured in a recirculating system, a high stocking density of 25 fish/100-L aquaria gained the highest growth compared to 15 and 20 fish/aquaria stocking densities, while all stocking densities had the highest survival rate (Samad et al., 2014). In estuary grouper, *E. salmoides*, fish cultured in a floating net cage at a stocking density of 15 fish/m^3 showed parallel results to 30 and 60 fish/m^3 in terms of food conversion efficiency, condition factor, survival and growth rates (Teng and Chua, 1978; Chua and Teng, 1979). In a flow-through system experiment by Salari et al. (2012), tiger grouper juvenile (*E. fuscoguttatus*) at different stocking densities of 1, 3 and 5 fish per liter found better growth and lower food conversion ratio was observed in fish at 3 individual per liter. Also, the stocking density of 2.06 – 3.09 kg/m^3 was found to be the most desirable for culturing juvenile hybrid grouper ♂ *E. lanceolatus x* ♀ *E. fuscoguttatus* in recirculating aquaculture systems when compared to 1.03 and 4.11 kg/m^3 (Shao et al., 2019). However, to increase grouper production in a floating net cage, a high stocking density could be an option, provided that the utilization of artificial hides has to be taken into account (Chua and Teng, 1979).

In fish and shrimp cultures, feed conversion ratio values range between 1.0 and 2.4 (Fry et al., 2018). In the present study, *E. coioides* cultured in a floating net cage at different stocking densities (20 – 40 fish/m^3) obtained low feed conversion ratios ranging from 0.08 – 0.57. Occasionally, an FCR of less than 1.0 has also been reported, notably in salmonid aquaculture (Boyd, 2021). The influence of stocking densities (15 – 25 fish/100-L aquarium) on the feed utilization of cultured grouper *E. coioides* has been previously investigated with significant findings depending on the use of culture systems, i.e., recirculation and flow-water system. Their findings revealed that the FI of *E. coioides* increases with increasing stocking density, while FCR was lowest at the highest stocking density in the recirculation system (Samad et al., 2014). These findings were parallel to the results of the present study. Boyd (2021) emphasized that a low FCR is an indicator of an efficient aquaculture operation.

5. Conclusion

Stocking density is an important aspect of aquaculture in order to obtain higher production. Our experiment revealed that the lower (20 fish/m^3) the stocking density of *Epinephelus coioides* (orange-spotted grouper) farmed in a floating net cage, the better the growth and survival rates, and the higher the feed utilization. Hence, lower stocking density is recommended for culturing an agile and voracious fish, such as the orange-spotted grouper *E. coioides*, in a floating net cage.

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