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Research Article

Growth Performance of White Snapper (*Lates calcarifer*) With Different Stocking Density in Hapa at Hatchery Laboratory Tual State Fisheries Polytechnic

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ABSTRACT

Maluku are known as the national fish barn and the largest fishing centre in Indonesia. One type of fish caught in Maluku is white snapper (*Lates calcarifer*), which is in high demand in the market. Therefore, intensification of aquaculture is essential. Determining factors for successful aquaculture include the stocking density of fry in aquaculture containers. The objective of this study was to determine effect of the stocking density on growth performance of white snapper cultivated in hapa. This observation took place over a month at the Hatchery Laboratory of the Aquaculture Technology Study Programme at the Tual State Fisheries Polytechnic. This study was used a completely randomised factorial design consisting of stocking densities of 10 fish/hapa, 15 fish/hapa, and 20 fish per hapa. Each treatment was repeated three times. The white snapper fish were obtained from the Tual Marine Cultivation Centre with a uniform size of 5-6 cm. The fish were cultivated in 40x40x40 cm hapa in fibre tanks using the RAS method and were fed commercial feed ad libitum. The growth parameters measured were length, weight, and growth rate of the fish. The data were analysed using one-way analysis of variance and followed by the DMRT test in the SPSS 22.0 program. The results showed that stocking density had a significant effect on the growth of white snapper during cultivation. The stocking density treatment of 10 fish/hapa had higher length and weight measurements each week of observation compared to other treatments. Thus, the lower the stocking density of white snapper in the hapa, the higher its growth. To achieve optimal growth in aquaculture, it is recommended to use a low stocking density of fish.

Keywords: growth performance, hapa, stocking density, white snapper

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INTRODUCTION

Indonesia is an archipelagic country with abundant marine resources. The province of Maluku is one of the regions in Indonesia with high potential for fishery resources. It is known as the national fish barn and is the centre of the largest fishery activities in Indonesia (Bawole et al. 2011). Data from the Badan Pusat Statistik (2025) shows that the capture fisheries production in Southeast Maluku Regency was 97,538,315 kg, while in Tual City it was 34,237,745 kg. This shows a significant increase from the previous year.

One of the products of capture fisheries is various types of fish. Fish inhabit all types of aquatic ecosystems, including freshwater, marine and brackish water ecosystems (Aslamiah et al., 2019). Fish live in various habitats, ranging from the surface to the middle and bottom of the water. Indonesia has been identified as having 1,000 species of freshwater fish and around 2,700 species of marine fish. One example of a marine fish is the white snapper (Rahardjo et al., 2011). This fish is a coral reef fish with excellent potential due to its relatively fast growth rate (Windarto et al., 2019). Most of the snapper production in Indonesia is obtained from wild catches. White snapper is one of the marine fish species with high economic value and high demand both domestically and for export.

To fulfill high market demand, intensive and optimal snapper farming is required. On the other hand, Yakin et al. (2018) mentions that snapper fish living in the sea are larger in size than those raised in brackish or fresh water. This is because they obtain more food from their natural habitat. Thus, an alternative solution is needed to overcome this problem so that snapper fish farming yields good results, is accepted in the market, and has a high selling price. Many factors influence the success of aquaculture, one of which is the stocking density in the aquaculture tank, especially when the fish are fry.

Stocking density is the number (biomass) of fry stocked per unit area or volume. The stocking density of fry will determine the intensity of maintenance and growth of the fish being farmed. Azhari et al. (2017) stated that stocking density is also influenced by water quality, feed, and fish size. This greatly determines the success of nursery farming. If the fry placed in the rearing tank are too dense, it will cause growth delays and even mass mortality. This is due to competition for feed and space among the fish in the cultivation tank.

There are many types of containers used in fish farming, one of which is hapa. Khatimah et al. (2023) explain that hapa nets can be used in hatchery activities as infrastructure in the adaptation process and to protect tilapia broodstock and fry from pests and diseases. Thus, it is hoped that fish fry production can be optimised. It is added that the technique of fish fry production using hapa nets has a higher growth rate and survival rate and provides good conditions for broodstock spawning. So far, white snapper fry cultivation in hapa nets has not been widely used. Studies on the growth of white snapper in hapa nets influenced by stocking density have also not been conducted, especially in the Southeast Maluku region. Fitrinawati and Utami (2023) have conducted a study on the growth of white snapper broodstock in floating net cages in Tual with a length of 18.8 ± 14.5 cm and a weight of 419.8 ± 293.0 g and a growth rate of 1.06 ± 0.73%. Therefore, further studies are needed to obtain optimal white snapper farming techniques, thereby increasing production and reducing wild catches.

METHODS

This study used a completely randomised design (CRD) with a factorial pattern and stocking density treatments consisting of 10 fish/hapa, 15 fish/hapa, and 20 fish/hapa. Each treatment was repeated three times. This study was conducted at the Hatchery Laboratory of the Tual State Fisheries Polytechnic from September to November 2024. Cultivation was carried out in cages in a 2-tonne fibre tank using the RAS (Recirculation Aquaculture System) method. The cages used were made of mesh, measuring 40x40x40 cm. The cages were placed according to the treatment and repetition..

The white snapper fish were obtained from the Tual City Marine Aquaculture Centre with a uniform size of 5-6 cm. Upon arrival at the laboratory, the fish were first acclimatised. This was done by placing the plastic packaging containing the snapper fry into a fibre tank and opening the plastic bag. The fish were left in the plastic bag, floating in the water for approximately 1 hour before being transferred to the rearing tank. After approximately 1 hour, the fish were allowed to come out of the plastic. When the fish came out of the plastic packaging into the rearing container, it meant that they had adjusted to the new environment. Once the fish had begun to adapt to the new environment, they were separated according to size and placed in hapa nets according to the treatment. Before being placed in the hapa, the fish were weighed and measured to ensure they were of a uniform size. The feed used is Megami GR 4, given twice daily in the morning and evening using the ad satiation method. Ensure that feeding is done on time to prevent the fish from cannibalising each other. The feed used is sized to match the fish's mouth opening so that the fish do not have difficulty eating it.

For observation, sampling was conducted in the morning. Before sampling, the fish were anaesthetised, therefore they should not be fed during sampling. Anaesthesia was performed using Arwana stabilizer ocean free 150. After that, the fish were placed in plastic containers to measure their total length using calipers with an accuracy of 0.1 cm. Analytical scales were used to measure weight. Calculations of absolute length growth and absolute weight growth were performed using the formula according to (Efendi, 2012) as follow in below. The data obtained were analysed using one-way analysis of variance and followed by the DMRT test in the SPSS version 22.0 programme.

- Absolute Length Growth (ALG)

$$ALG = L_t - L_0$$

Note:
ALG = Absolute Length Growth (cm)
L_t = Final Length (cm)
L_0 = Initial Length (cm)

- Absolute Weight Growth (AWG)

$$AWG = W_t - W_0$$

Note:
AWG = Absolute Weight Growth (g)
W_t = Final Weight (g)
W_0 = Initial Weight (g)

RESULTS AND DISCUSSION

1. Length and weight growth in week 0

The results of the study on the effect of stocking density on the body length and weight growth of white snapper cultivated in hapa at week 0 can be seen in Tables 1 and 2 below. Table 1 shows that stocking density had no effect on the body length of white snapper in week 0. (p>0,05).

Table 1. Results of the ANOVA for body length at week 0

	Sum of square	df	Mean square	F	Sig
Between groups	0,693	2	0,346	2,169	0,195
Contrast	0,634	1	0,634	3,970	0,093
Deviation	0,059	1	0,059	0,369	0,566
Within groups	0.958	6	0,160		
Total	1,651	8			

Table 2. Results of the ANOVA for body weight at week 0

	Sum of square	df	Mean square	F	Sig
Between groups	1,682	2	0,841	3,297	0,108
Contrast	1,643	1	1,643	6,440	0,044
Deviation	0,039	1	0,039	0,154	0,709
Within groups	1,531	6	0,255		
Total	3,213	8			

Table 2 shows that stocking density treatment had a significant effect on the body weight of white snapper in week 0 (p<0.05). To examine the differences in body weight between treatments, Duncan's test was used, with the results shown in Table 3.

Table 3. Duncan's test results between treatments

Treatments	a	b
Stocking density of 20 fish/hapa	5,220[a]	
Stocking density of 15 fish/hapa	5,883[ab]	5,883[ab]
Stocking density of 10 fish/hapa		6,2667[b]
Sig	0,159	0,389

Note: Different notation indicates differences between treatments

2. Length and weight growth in week 2

The results of the study on the effect of stocking density on the length and body weight growth of white snapper cultivated in hapa at the second week can be seen in Tables 4 and 6 below.

Table 4. Results of the ANOVA for body length at week 1

	Sum of square	df	Mean square	F	Sig
Between groups	0,885	2	0,443	5,752	0,040
Contrast	0,859	1	0,859	11,160	0,016
Deviation	0,026	1	0,026	0,344	0,579
Within groups	0,462	6	0,077		
Total	1,347	8			

Table 4 shows that the stocking density treatment affected the body length of white snapper in week 2 ($p<0.05$). The results of Duncan's test for differences in body length between treatments in week 2 are shown in Table 5.

Table 5. Duncan's test results between treatments

Treatments	a	b
Stocking density of 20 fish/hapa	6,743[a]	
Stocking density of 15 fish/hapa	7,236[ab]	7,236[ab]
Stocking density of 10 fish/hapa		7,50[b]
Sig	0,72	0,289

Note: Different notation indicates differences between treatments

Furthermore, the results of the study on the effect of stocking density on the growth of white snapper cultivated in hapa at the second week can be seen in Table 6.

Table 6. Results of the ANOVA for body weight at week 2

	Sum of square	df	Mean square	F	Sig
Between groups	1,653	2	0,827	5,122	0,050
Contrast	1,500	1	1,500	9,296	0,023
Deviation	0,153	1	0,153	0,949	0,368
Within groups	0,968	6	0,161		
Total	2,621	8			

Table 6 shows that the solid feed treatment had a significant effect on the body weight of white snapper in week 2 ($p<0.05$). The results of Duncan's test for body weight in week 2 are shown in Table 7.

Table 7. Duncan's test results between treatments

Treatments	a	b
Stocking density of 20 fish/hapa	6,333[a]	
Stocking density of 15 fish/hapa	6,556[ab]	6,556[ab]
Stocking density of 10 fish/hapa		7,33[b]
Sig	0,521	0,056

Note: Different notation indicates differences between treatments

3. Length and weight growth in week 4

The results of the study in week 4 can be seen in Tables 8 and 10. Table 8 shows that the stocking density treatment affected the body length of white snapper in week 4 ($p<0.05$). The results of Duncan's test for differences in body length between treatments in week 4 are shown in Table 9.

Table 8. Results of the ANOVA for body length at week 4

	Sum of square	df	Mean square	F	Sig
Between groups	0,411	2	0,205	4,176	0,073
Contrast	0,406	1	0,406	8,249	0,028
Deviation	0,005	1	0,005	0,102	0,761
Within groups	0,295	6	0,049		
Total	0.706	8			

Table 9. Duncan's test results between treatments

Treatments	a	b
Stocking density of 20 fish/hapa	7,280[a]	
Stocking density of 15 fish/hapa	7,590[ab]	7,590[ab]
Stocking density of 10 fish/hapa		7,80[b]
Sig	0,138	0,290

Note: Different notation indicates differences between treatments

Furthermore, the growth in body weight of white snapper cultivated in hapa cages in the fourth week can be seen in Table 10.

Table 10. Results of the ANOVA for body weight at week 4

	Sum of square	df	Mean square	F	Sig
Between groups	5,062	2	2,531	11,611	0,009
Contrast	4,489	1	4,489	20,596	0,004
Deviation	0,572	1	0,572	2,626	0,156
Within groups	1,308	6	0,218		
Total	6,370	8			

Table 10 shows that stocking density treatment affected the body weight of white snapper in week 4 ($p<0.05$). The results of Duncan's test for differences in body weight between treatments in week 4 are shown in Table 11.

Table 11. Duncan's test results between treatments

Treatments	a	b
Stocking density of 20 fish/hapa	6,713[a]	
Stocking density of 15 fish/hapa		8,113[b]
Stocking density of 10 fish/hapa		8,433[b]
Sig	1,000	0,420

Note: Different notation indicates differences between treatments

4. Length and weight growth in week 6

The results of the study on the effect of stocking density on the growth in length and body weight of white snapper cultivated in hapa cages in the sixth week can be seen in Tables 12 and 14 below.

Tabel 12. Results of the ANOVA for body length at week 6

	Sum of square	df	Mean square	F	Sig
Between groups	1,724	2	0,862	12,724	0,007
Contrast	1,540	1	1,540	22,733	0,003
Deviation	0,184	1	0,184	2,716	0,150
Within groups	0,407	6	0,068		
Total	2,131	8			

Table 12 shows that stocking density treatment affected the body length of white snapper in week 6 ($p<0.05$). The results of Duncan's test for differences in body length between treatments in week 6 are shown in Table 13.

Table 13. Duncan's test results between treatments

Treatments	a	b
Stocking density of 20 fish/hapa	7,610[a]	
Stocking density of 15 fish/hapa	7,813[a]	
Stocking density of 10 fish/hapa		8,623
Sig	0,376	1,000

Note: Different notation indicates differences between treatments

Furthermore, the results of the study on the effect of stocking density on the growth of white snapper fish cultivated in hapa cages in the sixth week can be seen in Table 14.

Table 14. Results of the ANOVA for body weight at week 6

	Sum of square	df	Mean square	F	Sig
Between groups	8,860	2	4,430	25,014	0,001
Contrast	8,857	1	8,857	50,013	0,000
Deviation	0,002	1	0,002	0,014	0,910
Within groups	1,063	6	0,177		
Total	9,922	8			

Table 14 shows that stocking density treatment affected the body weight of white snapper in week 6 ($p<0.05$). The results of Duncan's test for differences in body weight in week 6 are shown in Table 15.

Table 15. Duncan's test results between treatments

Treatments	a	b	c
Stocking density of 20 fish/hapa	7,016[a]		
Stocking density of 15 fish/hapa		8,266[b]	
Stocking density of 10 fish/hapa			9,446[c]
Sig	1,000	1,000	1,000

Note: Different notation indicates differences between treatments

5. Absolute length growth

The results of the study on the effect of stocking density on the absolute growth rate of farmed white snapper in hapa cages can be seen in Table 16 below.

Table 16. Result of the Anova for absolute length growth rate

	Sum of square	df	Mean square	F	Sig
Between groups	0,233	2	0,116	0,697	0,534
Contrast	0.198	1	0,198	1,187	0,318
Deviation	0,035	1	0,035	0,208	0,665
Within groups	1,001	6	0,167		
Total	1,234	8			

Table 16 shows that stocking density had no effect on the absolute growth rate of white snapper ($p<0.05$). Duncan's test results show that there was no difference in absolute growth rate between treatments, as shown in Table 17.

Table 17. Duncan's test results between treatments

Treatments	a
Stocking density of 20 fish/hapa	1,710[a]
Stocking density of 15 fish/hapa	1,760[a]
Stocking density of 10 fish/hapa	2,073[a]

Sig	0,332

Note: Different notation indicates differences between treatments

6. Absolute weight growth

The results of the study on the effect of stocking density on the growth rate of white snapper cultivated in hapa can be seen in Table 18 below.

Tabel 18. Hasil uji Anova padat tebar terhadap laju pertumbuhan panjang mutlak

	Sum of square	df	Mean square	F	Sig
Between groups	2,892	2	1,446	5,633	0,042
Contrast	2,870	1	2,870	11,180	0,016
Deviation	0,022	1	0,022	0,086	0,779
Within groups	1,541	6	0,257		
Total	4,433	8			

Table 18 shows that stocking density treatment affected the growth rate of absolute weight of white snapper ($p<0.05$). The results of Duncan's test for differences in absolute weight growth rates between treatments are shown in Table 19.

Table 19. Duncan's test results between treatments

Treatments	a	b
Stocking density of 20 fish/hapa	1,796[a]	
Stocking density of 15 fish/hapa	2,383[ab]	2,383[ab]
Stocking density of 10 fish/hapa		3,180[b]
Sig	0,206	0,102

Note: Different notation indicates differences between treatments

White snapper has long been known as a freshwater fish for consumption, so consumer acceptance will be easy. Therefore, this species must be intensively cultivated to increase production in order to meet demand. One factor that influences the intensification of fish farming is stocking density (Djunaedi et al. 2016). According to Ronald et al. (2014), the use of stocking density in intensive cultivation will have an impact on the decline in water quality. This is due to the increase in waste and feed residues and faeces. Thus, it will affect the growth of farmed fish. Yuliati et al. (2003) stated that the higher the stocking density, the more intensive the maintenance level. Fish density is very important for their comfort. According to Hepher and Pruginin (1981), high stocking densities can cause stunted growth, so that growth stops at a certain density. This occurs because the carrying capacity of the environment has been reached. Therefore, high stocking densities will cause an increase in feed consumption, metabolic waste, oxygen consumption, and can reduce water quality. A decline in water quality will cause stress in fish, resulting in stunted growth and increased susceptibility to mortality.

To measure the success of stocking density using growth indicators. Effendie (2002) states that growth is an increase in length or weight over a period of time that is influenced by internal and external factors, some of which can be controlled and some of which cannot be controlled. Based on the results of the study, it was shown that stocking density had a significant effect ($p>0.05$) on the length and weight growth of tilapia broodstock kept for 4 weeks in a hapa. Each stocking density treatment had different average length and weight measurements each week. In this study, the growth of tilapia at a density of 10 fish/hapa resulted in higher length measurements each week. This was almost the same as the treatment with 15 fish/hapa. Meanwhile, low growth was observed in the treatment with a stocking density of 20 fish/hapa. The results of this study differ from those of Djunaedi et al. (2016), who stated that differences in stocking density did not affect the absolute growth and growth rate of Larasati tilapia in brackish water ponds. In the research of Djunaedi et al. (2016), saltwater tilapia were used and adapted to the appropriate salinity conditions. Higher stocking densities resulted in heterogeneous growth, causing the weight of the farmed tilapia to vary greatly. Similar results were also shown by Alhassan et al. (2012), who raised tilapia fry in hapa in concrete ponds with freshwater media at densities of 8, 10 and 12 fish/m3. It was explained that higher stocking densities caused heterogeneous growth, resulting in highly variable growth rates among the tilapia being raised.

The high growth rate in the treatment with a stocking density of 10 fish/hapa was explained by Riana et al. (2021) as being due to the energy obtained through feed being optimally used for growth. This is in line with the opinion of Effendie (2002), who stated that feed consumed by fish will produce energy that is used to maintain the body, fish movement, replace damaged body cells, and for growth. Conversely, the low growth in the high stocking density treatment was due to the uneven and inconsistent efficiency of fish in stimulating their growth as a result of differences in the amount of feed that could be absorbed by the fish in each treatment. This is also supported by Saputra et al. (2013), who stated that one of the factors that maximally affects fish growth is the amount of feed that fish can consume each day and the daily feed consumption rate.

According to Sihite et al. (2020), energy obtained from feed is first used for fish maintenance, and then excess energy is used for growth. This is also reinforced by the statement of Oliveira et al. (2012) that stocking density directly affects survival, growth, behaviour, water quality and feeding. Islami et al. (2013) added that competition at low stocking densities will result in better growth because it provides opportunities to obtain more energy and utilise it for growth.

In addition to feed and energy, another factor that affects fish growth due to different stocking densities is the space available for fish to move within the cage. Setiawan (2009) explains that as fish grow in length and weight, their space to move becomes more limited, which disrupts their physiological processes and behaviour. Furthermore, it can also cause competition for food, which can ultimately reduce the health and physiological condition of the fish (Agus et al. 2013; Samad et al. 2014). Low stocking density will not affect oxygen consumption levels, appetite and ammonia accumulation will also be low.

The low growth rate in the treatment with a stocking density of 20 fish/hapa was due to the higher stocking density affecting the quality and carrying capacity of the living media. According to Widiastuti (2009), a high stocking density of fish in a container will cause competition between individual fish for feed, so that at a lower stocking density, greater growth will be achieved.

Another factor that can be explained is that high stocking density causes stress on the environment, especially in small aquaculture environments. In this study, a 40x40x40 cm hapa was used. This will certainly have an impact on the growth of farmed tilapia. This is in line with Diansari et al. (2010), who stated that high stocking density will result in higher pressure on the environment. The cause is increased competition for space, food requirements and metabolic waste, which in these conditions will reduce individual survival. Growth at low stocking densities is faster due to lower competition. Djauhari et al. (2025) also stated that fish reared at the highest stocking density in hapa produced the lowest values. This is because the energy allocation that should be more focused on growth is used more to cope with environmental stressors in the form of extremely high stocking densities. Extreme stocking density stressors significantly disrupt the physiology of enzyme production, which plays a role in digestive metabolism and feed nutrient absorption (Li et al. 2024).

CONCLUSION

Stocking density significantly affected the increase in length and weight as well as the absolute weight growth rate of white snapper fish raised in fish cages. Stocking density of 10 fish per cage had a higher growth rate compared to other treatments.

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