Effect of Stocking Density on Survival Rate and Growth of Tilapia (*Oreochromis niloticus* Linnaeus, 1758) in Round Container with Water Current Combined with Venturi Aeration System

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**Authors’ contributions**

This work was carried out in collaboration among all authors. Author AY designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SN and IR managed the analyses of the study. Author IBBS managed the literature searches. All authors read and approved the final manuscript.

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**ABSTRACT**

The aim of this research is determine of the optimal stocking density for survival rate and growth of tilapia in round container with water current combined with venturi aeration system. Place of research in the Aquaculture Laboratory, Building 4 Faculty of Fisheries and Marine Sciences, Universitas Padjadjaran. The research method used is experimentally with using the Completely Randomized Design (CRD) method which consists of three treatments, there are 15 fish, 22 fish, 30 fish, with five replications. Using water of 15 L per container. The fish used are 3-5 cm tilapia fingerlings. Fish were maintained for 40 days. The feed given is 5% from biomass which is adjusted every 10 days. The parameters observed were survival rate (SR) and observed everyday, daily grow rate (DGR), feed conversion ratio (FCR) and feed efficiency were observed every 10 days. The result was significantly different from the analysis of variance (ANOVA) with the F test at

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Keywords: Stocking density; survival rate; growth; tilapia; round container; water current; venturi aeration; microbubble.

1. INTRODUCTION

Tilapia is a commodity that is in great demand. The most popular cultural species is Nile tilapia (Oreochromis niloticus), accounting for 78% of total production, with China accounting for 65% of total species. Other Asian countries such as the Philippines, Indonesia and Thailand also produce significant amounts of tilapia [1]. Intensive aquaculture is followed by increased production with intensive aquaculture systems at high stocking densities. However, high stocking density has a problem that can affect fish growth. Modification of containers in aquaculture engineering was made to be able to support fish productivity by optimizing water quality and fish growth. The advantage of a round container is that it provides uniform water quality [2]. The advantage of the water current is that the fish is actively moving but their oxygen needs will still be met to increase growth. The need for dissolved oxygen is needed to meet the needs of fish so that the use of aeration is very important. The venturi aeration system can produce microbubbles which can optimize the level and amount of oxygen transfer. Microbubbles having characteristics such as large gas-liquid interface areas, long residence times in the liquid phase and rapid dissolution rates so they have the advantage of being able to dissolve oxygen in water [3]. In the fishing industry, this tool is used to increase oxygen levels in ponds. The round container with a current and venturi aeration system can support fish growth so that it can help meet the challenges of a high stocking density aquaculture system. Then it is necessary to research to determine the effect of different stocking densities on the survival rate and growth of tilapia in a round container with water current combined with a venturi aeration system.

2. MATERIALS AND METHODS

The research was conducted in the Aquaculture Laboratory, Building 4 Faculty of Fisheries and Marine Sciences, Universitas Padjadjaran. The tools used are 15 gallons with diameter of 26 cm x 48 cm height x 19 liter volume, 15 buckets, water pumps, PVC pipes of ⅜ inch and ¾ inch sizes, tap sizes of ⅜ inch, digital scales, baskets, scoop net, fiber tub. The material used are 3-5 cm tilapia fingerling size of 3-5 cm from Balai Benih Ikan Cibiru, West Java, commercial feed with a protein content of 31-33%, dacron, and using water of 15 L per container. The research method used is experimentally with using the Completely Randomized Design (CRD) method which consists of three treatments and five replications with different stocking densities on a round container with water current combined with venturi aeration system. This research was conducted using 0.1 ms⁻¹ for water flowing speed.

1. Treatment A: stocking density of 15 tilapia fingerling (100% density)
2. Treatment B: stocking density of 22 tilapia fingerling (150% density)
3. Treatment C: stocking density of 30 tilapia fingerling (200% density)

2.1 Container Design

In this research gallon as a maintenance container. In the middle of the gallon, there are two pipes of different sizes. The larger pipe (¾ inch) is outside the smaller pipe (⅜ inch). The larger pipe has the same height as the gallon and the bottom is hollow so that dirt can be lifted together by water and into the inside pipe (smaller pipe), while the smaller pipe has the same height as the surface of the water container maintenance and the bottom is connected to the outlet channel. The water used is the recirculation system. Water comes out through the outlet, then the water is filtered first using dacron. After that, the water filtered by dacron will fall and be reservoired in a bucket. The water in the bucket will be pumped through a pipe and connected to venturi aeration system, then it will produce a water current of 0.1 ms⁻¹ the speed can be balanced by the tap (Fig. 1.).

In the middle of the gallon, the larger pipe (⅜ inch) has size of 42 cm and the smaller pipe (⅜ inch) has size of 34 cm. For outlet used ⅜ inch
pipe with size of 37 cm, one tap, two L-shaped pipe connectors. From water pump until venturi aeration system as a water inlet, there are used ½ inch pipe with size of 119 cm, one tap, four L-shaped pipe connectors, one T-shaped pipe connector.

2.3 Observation Parameters

The parameters observed in this research consisted of:

2.3.1 Survival rate

Survival can be determined by comparing the number of fish that live at the end and the beginning of the research. Observation of the survival of tilapia is done every day by recording the number of dead fish. The percentage of fish survival is calculated using a formula [4].

\[ SR = \frac{N_t}{N_0} \times 100\% \]

Note:

\( SR \) = Survival rate (%)
\( N_t \) = Number of live fish at the end of fish rearing (40th day) (individual)
\( N_0 \) = Number of fish at the beginning of fish rearing (individual)

2.3.2 Daily growth rate

Data to calculate the daily growth rate is obtained from observations during the maintenance of tilapia fingerling. Then sampling and weighed to get the average weight of rearing fish. The data is taken once every 10 days during the research. Daily growth rate is calculated using the calculation formula [4].

\[ DGR = \frac{\ln W_t - \ln W_0}{t} \times 100\% \]

Note:

\( DGR \) = Daily Growth Rate (%g/day)
\( W_t \) = Average weight fish at the end of fish rearing (40th day) (g)
\( W_0 \) = Average weight fish at the beginning of fish rearing (g)
\( t \) = Duration of observation (40 days)

2.3.3 Feed Conversion Ratio (FCR)

Data to calculate the feed conversion ratio is taken by weighing fish biomass every 10 days and 5% of the biomass is used as a measure of the amount of feed given to tilapia that is kept, while the biomass of fish that die during the study is weighed and recorded. Feed Conversion Ratio (FCR) ratio is used to determine the amount of feed given by body weight to be produced, tested at the end of the observation with the calculation formula [5].
FCR = \frac{F}{(W_t+D)-W_o}

Note:

FCR = Feed Conversion Ratio
F = Amount of feed given during the study (g)
W_t = Biomass at the end of fish rearing (40th day) (g)
W_o = Biomass at the start of fish rearing (g)
D = Biomass of fish that died during the observation (g)

2.3.4 Feed efficiency

Data to calculate the feed efficiency is taken by weighing fish biomass every 10 days and 5% of the biomass is used as a measure of the amount of feed given to tilapia that is kept, while the biomass of fish that die during the study is weighed and recorded. The value of feed efficiency can be determined by the formula [6].

FE = \frac{(W_t+D) - W_o}{F} \times 100\%

Note:

FE = Feed Efficiency (%)
W_0 = Weight of fish biomass at the beginning of fish rearing (g)
W_t = Weight of fish biomass at the end of fish rearing (40th day) (g)
F = Amount of fish feed given during the observation (g)
D = Weight of fish that died during the observation (g)

2.4 Data Analysis

Analysis of the data used is the analysis of variance (ANOVA) with the F test at 95% confidence intervals to determine whether a treatment has a significant effect on survival rate, daily growth rate, feed conversion ratio, feed efficiency. If the treatment shows significantly different, then the Duncan Test is performed.

3. RESULTS AND DISCUSSION

Based on research that has been carried out following the results along with a discussion of each parameter observed.

3.1 Water Quality

Water quality parameter based on this research are dissolved oxygen (DO) and ammonia levels (Table 1.)

3.2 Survival Rate

Data from the calculation of the survival rate for 40 days rearing fish showed the highest survival rate at treatment A was 78.67%, then treatment B was 60.91% and treatment C was 46%. Based on testing with the F test at a 95% confidence interval showed that there were significant differences in the survival rates of the three treatments. Duncan Test has then performed the result is treatment B with treatment C was not significantly different, but both were significantly different from treatment A as the treatment with the best results. The viability of tilapia fingerling kept for 40 days in each treatment is shown in Fig. 2.

Fish that survived in treatment A were in between three treatments. Survival rates decrease with increasing stocking densities, indicating that the higher stocking densities will be followed by increased fish mortality. Treatment A was significantly different from treatment B and treatment C, then treatment B and treatment C were not significantly different, showing that each fish in the round container had optimal stocking density to be able to maintain its life, if it exceeds the optimal limit then the percentage of fish that survive the feed will be lower.

Based on the results of the study, treatment A had a higher survival rate. The size of 3-5 cm tilapia fingerling used in this study has a minimum survival rate of 60% [7], then treatment A which results in survival of 78.67% has the best percentage of the three treatments.

The low survival rate occurs because more and more fish are kept in containers, it will affect the less space for fish and cause the fish to become stressed, thus placing greater pressure on the fish to continue to maintain its life, therefore fish deaths can occur. The treatment of high stocking densities causes the low consumption of feed on fish which can stress fish and eventually experience death [8]. Tilapia is an aggressive fish so stocking density can affect their competition in space and permanent stress caused by overcrowding [9].

High stocking density can also affect the decline in water quality of maintenance media such as high ammonia values which can affect fish mortality. Treatment C which is the highest stocking density has a higher ammonia value among the three treatments, this is also evidenced by the turbidity of maintenance media.
Table 1. Water quality of tilapia fingerling

| Parameter                  | Treatment   |
|----------------------------|-------------|
|                           | A (15 fish) | B (22 fish) | C (30 fish) |
| Dissolved Oxygen (mg L⁻¹) | 5-6,3       | 5-6,2       | 4,4-5,9     |
| Ammonia (mg L⁻¹)          | 0,003-0,02  | 0,003-0,06  | 0,003-0,06  |

![Fig. 2. Survival rate of tilapia fingerling](image)

in treatment C (Fig. 3). There is a waste of feed at a higher turbidity level which may be caused by a decreased appetite. Turbidity of maintenance media can affect the gills of fish because it works harder to filter water and obtain oxygen. Increased mortality of tilapia at high turbidity can be caused by gill blockage which has an impact on the efficiency of gas exchange which will affect growth and ultimately will lead to death [1].

3.3 Daily Growth Rate

Data from the calculation of the daily growth rate for 40 days rearing fish showed the highest daily growth rate in treatment A was 3.68%, then treatment B was 3.44% and treatment C was 3.14%. Based on testing with the F test at 95% confidence interval showed that there were significant differences in the daily growth rate of the three treatments. Then the Duncan Test was carried out. The result was that treatment A was significantly different from treatment C, treatment B was not significantly different from treatment A and treatment C, treatment C was significantly different from treatment A. The daily growth rate of tilapia fingerling maintained for 40 days in each treatment is shown in Fig. 4.

Treatment A is the treatment with the lowest stocking density (15 fish) being the best treatment with the highest value of the growth rate of 3.68%. Giving a water current can give the fish an advantage in being able to save energy to get oxygen dissolved in water, fish do not have to pump water on the gills because they only need to open their mouths to ventilate the gills. Then, oxygen is important in the process of metabolism for growth [10].

High stocking density can affect the decline in fish growth due to competition in the space that triggers stress that can inhibit fish growth. The maximum increase in fish biomass is found in the lowest stocking densities and decreases with increasing stocking densities due to better feed utilization and unstressed conditions at low stocking rates [11]. Besides, increased stocking densities can disrupt water quality which can also interfere with growth [12].

The daily growth rate of the three treatments on the research results shows that the value is still in the same range of around 3% (Fig. 4.), it proves that the influence exerted on the round container with water current combined with venturi aeration system can provide a high daily growth rate, but it is also undeniable that
stocking densities have a greater effect so that treatment A is obtained with the highest daily growth rate and the daily growth rate of treatment C is the lowest. One of the advantages of a round container with water current combined with venturi aeration system is that it provides better water quality, such as the availability of oxygen to meet the needs of fish. However, this is not enough to create a stocking density that exceeds the optimal limit can have the same or even greater daily growth rate with a daily growth rate at low stocking densities, it shows that stocking densities greatly affect the daily growth rate of fish. The stocking density of fish that is too high can reduce water quality, fish growth becomes slow, the survival rate of fish is low. High stocking density will disrupt the growth rate even though food needs are fulfilled. This is due to competition in fighting for space [13].

3.4 Feed Conversion Ratio (FCR)

Data from the calculation of the feed conversion ratio for 40 days of fish rearing showed the highest feed conversion ratio in treatment C was 1.81 then in treatment B was 1.38 while treatment A was 1.19. Based on testing with the F test at a 95% confidence interval showed that there were significant differences in the feed conversion ratio of the three treatments. Then the Duncan Test was carried out. The result was that treatment A with treatment B was not significantly different, treatment C was significantly different from treatment A and treatment B. The conversion ratio of tilapia fish kept for 40 days in each treatment is shown in Fig. 5.

Feed Conversion Ratio (FCR) is the ratio between the weight of feed given to produce one kilogram of meat. Therefore, the higher the FCR value, the more feed is given to produce one kilogram of flesh. The lower FCR value indicates that the more efficient the feed and the feed eaten were used well by fish for meat formation. Based on the results of the study, treatment A has the lowest FCR value of 1.19 so that it becomes the best treatment. That is because the round container has water current that can make it easier for fish to swim so that the fish can metabolize better and the feed provided is more efficient. Whereas the presence of venturi aeration can help meet the dissolved oxygen demand of fish to metabolize faster. High DO concentrations can increase fish metabolism and growth. Increased oxygen consumption after meals can occur due to certain dynamic actions, such as metabolic requirements to digest and assimilate nutrients from feed [14]. The value of a good Feed Conversion Ratio (FCR) for tilapia is 0.8-1.6 [15]. Treatment A has a FCR value of 1.19 while treatment B which is statistically not significantly different from treatment A has an FCR value of 1.38. Based on these standards, both treatments indicate that they have a good FCR for tilapia.

![Fig. 3. Media conditions of tilapia fingerling day 40th (a) treatment a (b) treatment b (c) treatment c](image-url)
Fig. 4. Daily growth rate of tilapia fingerling

Treatment C has the highest FCR value because in treatment C stocking density has exceeded optimal so that it can reduce the ability to convert feed into meat. When high stocking densities make tilapia foraging through their eyesight, feed loss will increase because high biomass induces water turbulence at mealtimes, therefore FCR can increase [9]. In general, energy from feed consumed will be used for maintaining energy and the rest will be used for growth energy. Stress arising from the higher stocking density will increase maintenance energy. Thus this will reduce the energy that should be for growth [16].

FCR of tilapia in the floating net cage system for each stocking density of 50, 75, 100, 125/m³ is 1.81, 1.92, 1.97 and 2.05 [17], whereas stocking densities of 50, 100 and 150/m³ FCR value are 1.76, 1.99 and 2.31 [18]. The FCR of tilapia in the aquaponic system for each stocking density of 106, 142, 177/m³ was 2.19, 2.41, 2.69 [19]. The FCR of tilapia in tanks with each stocking density of 1, 5, 10, 15 kg/m³ is 2, 2, 2, 2.2 [11]. These results indicate that there is a uniform pattern with the research results obtained where an increase in stocking density will be followed by an increase in the FCR number, where the greater the FCR value is the less efficient. The influence of water current from venturi aeration can increase the growth of fish because the fish will be actively moving, so the need for feed and oxygen can be fulfilled for the metabolic process. The optimal speed of water current can increase fish growth by increasing protein synthesis, the amount of glycogen and white muscle fiber. Besides, it can optimize the feed conversion ratio [20].

3.5 Feed Efficiency

Data from the calculation of the feed efficiency for 40 days of fish maintenance showed the highest feed efficiency in treatment A was 85.01% then in treatment B was 74.14% and finally, treatment C was 56.3%. Based on testing with the F test at a 95% confidence interval showed that there were significant differences in the efficiency of the three feed treatments. Furthermore, the Duncan test was carried out. The results were that treatment A with treatment B was not significantly different, treatment C was significantly different from treatment A and treatment B. The feed efficiency of tilapia feed which was maintained for 40 days in each treatment is shown in Fig. 6.

Treatment A is the best treatment that has the highest percentage of feed efficiency of 85.01% because the higher the feed efficiency percentage, the greater the ability of tilapia fingerling to utilize the feed provided. The percentage of feed efficiency mutually influences the high or low feed conversion ratio (FCR). Maintenance of tilapia fingerling carried out in a round container have currents with venturi aeration can help treatment B (22 fish) have the results of efficient use of feed that is not significantly different from treatment A (15 fish). Feed efficiency is said to be good because it has feed efficiency values above 50% [21].
Round container is good for fish farming activities, one of which is because the solid in round container that settles can quickly be watered through the center channel of the container [2], so as to provide better water quality to support the digestibility of feed in fish. Besides, the water current can stimulate fish to keep moving. When physical performance such as movement speed increases, oxygen consumption increases until the maximum value is reached [22]. Increased oxygen consumption needs to be supported by the availability of sufficient dissolved oxygen in the waters. This venturi aeration will produce microbubble so that it can contribute to the availability of dissolved oxygen. Whereas the presence of venturi aeration will produce microbubble so that it can contribute to the availability of dissolved oxygen. Even so, stocking densities in round containers still have optimal limits that can affect fish growth.

In treatment C, high stocking density will be followed by high feeding, but that does not mean it will provide high growth as well. Feed that is eaten by tilapia fingerling in the maintenance of high stocking densities is not entirely converted into meat, but is first used for activity and basal
metabolism. High stocking density makes fish stress so it requires more energy to maintain its life than in low stocking density. High stocking densities cause stress and inhibit fish growth, which leads to an increase in energy requirements and hence results in decreased growth performance and feed efficiency [23].

4. CONCLUSION

The higher of stocking density, it will affect fish growth because it affects the space for fish in container and trigger stress, so it can decrease fish growth. The results of this research can be concluded that stocking density influences the growth of tilapia fingerling maintained in round container with water current combined with venturi aeration system, the stocking density of 15 fish/15 L produces the highest productivity with 78.67% survival rate, daily growth rate was 3.68%, the feed conversion ratio was 1.19 and the feed efficiency was 85.01%.

CONSENT

All authors declare that written informed consent was obtained from the patient (or other approved parties) for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editorial office/Chief EditorEditorial Board members of this journal

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Authors have declared that no competing interests exist. In addition, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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