The growth and survival rate in lettuce aquaponic systems
(*Latuca sativa*) of eels in various stocking densities of eel
(*Monopterus albus*)

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**Abstract.** *Monopterus albus* is a freshwater fish species with the potential to be developed as a farmed fish in the future. The eel demand for domestic and export markets is increasing every year. For the market’s increasing demand, it is necessary to cultivate good technology and management in order to obtain good results. One way to conduct fish farming is by optimizing the stocking density and quality of the water in the maintenance container. One of the systems used is the Aquaponics system. Aquaponics are one of the cultivation technologies available that combine fish farming with water plants. This study aimed to find out the influences of the eel stocking density differences on the growth rate and survival rate of eels in aquaponics. The experiment used a completely randomized design (CRD) with two of five treatments and five replications; P0 (20 eels m⁻²), P1 (10 eels m⁻²), P2 (30 eels m⁻²) and P3 (40 eels m⁻²). The observed parameters were the growth rate and survival rate of the eels. The analysis of the data was conducted using Analysis of Variance (ANOVA) and this was then followed by Duncan's Multiple Range Test. Based on the research, the survival rate (p <0.05) showed that there was a significant difference in the rate of growth (p <0.05). Based on the research results, the stocking density of 30 eels is m⁻². We obtained the highest specific growth rate in the amount of 0.339 ± 0.116% and the highest survival rate was 79%.

1. Introduction
Eels are a type of freshwater fish that has the potential to be developed as an aquaculture fish in the future. The demand for eels in both the domestic and export markets is increasing every year. The eel’s habitat is threatened due to the contamination of river waters from urban areas, where the wash-off enters the rice fields and swamps. There is also the widespread use of pesticides [1]. Due to the increased threat to the existence of eel populations in nature, it is necessary to develop eel farming technology that can be applied in the community. Currently, the eel farming that has been carried out still uses mud with a mixture of other organic materials as a natural medium for the eels. However, this has become one of the obstacles in the cultivation of eel, as the preparation of the ground with mud soil requires a variety of mixed materials and the time needed for the preparation of the container is long. It is a form of less efficient harvesting that requires further maintenance and more time for preparation. As well as the difficulty involved in monitoring the development and continuity of the eels during the uncontrolled cultivation, efforts to intensify eel cultivation are difficult to do in an eel production that is relatively unpredictable. To overcome this, the cultivation of eels can be done with clear water media because in
the medium of clear water, the eels will be more easily controlled and it will be possible to observe its growth and survival. One technology that uses clear water media is aquaponics technology.

Aquaponics is a technological innovation to reduce waste and increase productivity due to the lack of cultivated land. Aquaponics is a bio-integration method that combines aquaculture and plants with a principle of recirculation to work in limited land and water resources [2]. The principle of aquaponics technology is to save water and land use so as to improve business efficiency through the utilization of nutrients from the remaining food and metabolism of fish; therefore it becomes an eco-friendly aquaculture activity. Aquaponics technology uses a recirculation system designed to increase fish productivity in a relatively small total volume of water by absorbing the organic waste through plants. Aquaponics systems require water plants (vegetables) that are useful as biological filters in aquatic ecosystems. The aquaponic system does not use inorganic fertilizers (chemical compounds) in its maintenance, but only the medium of water that has been enriched by the metabolic waste of fish that can be used as a planting medium for aquatic plants [3]. The plants function as a filter for the aquaculture wastewater that is reused for fish cultivation. One of the aquatic plants that can be used for aquaponics is lettuce. According to [4], lettuce is a filter medium that is effective at absorbing nitrite [4]. In this study, the management of eel culture waste using aquaponics technology with lettuce was carried out. With this research, it is expected that the survival and growth of eels can be proven to increase.

2. Materials and methods

2.1. Place and time research

The study was conducted from August 2016 to September 2016 at the Faculty of Fisheries and Marine, Airlangga University.

2.2. Tools and materials

The tools used in this study were aquariums measuring 30 x 20 x 50 cm³, circulation pumps, pH-pen, thermometers, plastic tubs, analytic scales, rulers, ammonia testkit and a DO testkit.

The material used in this study consisted of eels that were 15-25 cm in size and ± 6 g in weight, up to as many as 500 individuals. The lettuce, using the Romain variant, was 2 weeks old.

2.3. Procedure

The design used in this study was a Completely Randomized Design (CRD). This study consisted of five treatments with four replications. The treatment given in this study was the difference in the eel stocking density, P1 = 10 eels m⁻², P2 = 20 eels m⁻², P3 = 30 eels m⁻² and P4 = 40 eels m⁻².

The aquaponic system was designed by being placed in a plant container over a fish pond. The plant containers were equipped with the planting media as a treatment serving as a place for the plants to stand. The plants used as plant containers were given 1 inch diameter holes as channel outlets. The channel inlets were directly connected to a pump that pumped pool water into the plant maintenance container. The channel outlet drained water from the plant maintenance container into the eel enlargement tub. The water flow uses the principle of recirculation, so then the water from the eel cultivation process that entered the plant maintenance container was used as a source of water in the process of fish cultivation.

The feed given was in accordance with the eel’s eating habits. Artificial feed was given in the form of pasta with more than 35% protein content. Feeding was done every evening because eels are nocturnal, and so actively search for food at night. The maintenance of the eels was carried out for 30 days.

2.4. Research

The parameters in this study were the survival and growth rate of the eels and the water quality, which included temperature, pH, dissolved oxygen and the water maintenance media during the study. Specific Growth Rate (SGR) was the individual weight gain rate in percent per day. SGR was calculated using the following:

\[ \text{SGR} = \frac{(\ln \text{We} - \ln \text{Ws})}{d} \times 100 \]

Description:
Thus the treatment of 40 eels showed the lowest treatment yield of 0.636 cm absolute length eel that was 0.2%. The results of Duncan's Multiple Range Test can be seen in Table 1. The highest growth rate occurred in the stocking density of 30 eels m⁻², which was 0.339%, while the lowest growth rate occurred in the stocking density of 40 eels m⁻² that was 0.2%.

Table 1. Percentage of the Specific Growth Rate (SGR), mean absolute length and eel survival rate during the research time

| Treatment | Specific Growth Rate (%) ± std | Absolute Length Eel (cm) ± std | Survival rate Eel (%) ± std |
|-----------|-------------------------------|-------------------------------|-----------------------------|
| P1 (10 eels) | 0.307± 0.42                   | 0.584± 0.03                   | 56± 8.94                    |
| P2 (20 eels) | 0.215± 0.05                   | 0.406± 0.08                   | 44± 5.47                    |
| P3 (30 eels) | 0.339± 0.11                   | 0.636± 0.18                   | 78.6± 7.66                  |
| P4 (40 eels) | 0.200± 0.03                   | 0.294± 0.08                   | 36± 8.94                    |

The results of the research on eel growth in length in different stocking densities were obtained from calculating the initial length difference and their length at the end of the study. Based on the ANOVA test, the treatment resulting in the eel stocking density difference (Monopterus albus) in the aquaponics system of lettuce produced an absolute length of eel that was significantly different (P <0.05) from the start. The results of Duncan's Multiple Range Test can be seen in that the treatment of 30 eels m⁻² showed the highest treatment yield of 0.636 cm and the treatment of 40 eels m⁻² showed the lowest treatment yield of 0.294 cm.

The level of survival is the percentage value of the number of live fish during the maintenance period. The results of the ANOVA test calculation showed that the comparison between the treatments showed there to be a significant difference (P <0.05). The results of these observations show that in the eel aquaponics system, the stock density factor influences the life of the eels. The level of the survival of the eels that were kept for 30 days ranged from 36% to 79%. The highest value was achieved in the treatment of 30 m⁻² eels at 79% and the lowest value was in the treatment of 40 m⁻² eels at 36%.

Water quality in fish farming includes every variable that affects fish management, survival, breeding, growth and production. Poor water quality results in slow growth of fish. The water quality parameters measured included temperature, pH, dissolved oxygen (DO) and ammonia during the study. The temperature and pH were measured every morning and evening, and the level of dissolved oxygen
was measured every 3 days in the morning and evening. The average water quality during the study has been shown in Table 2.

Table 2. Average water quality parameters in the eel cultivation media

| Perlakuan | Temperatur (°C) | pH | DO (mg l⁻¹) | Ammonia (mg l⁻¹) |
|-----------|----------------|----|-------------|------------------|
| P1 (10 eels m⁻²) | 25-32 | 7.4-8.4 | 4-6 | 0.03-0.04 |
| P2 (20 eels m⁻²) | 25-32 | 7.4-8.4 | 4-6 | 0.03-0.06 |
| P3 (30 eels m⁻²) | 25-32 | 7.4-8.4 | 4-6 | 0.05-0.18 |
| P4 (40 eels m⁻²) | 25-32 | 7.4-8.4 | 4-6 | 0.03-0.53 |

Based on research has been done, the temperature, pH and dissolved oxygen are relatively the same. The average temperature during the study was 29°C, pH was 8 and dissolved oxygen was 4 mg l⁻¹. The highest average ammonia is found in 40 treatments m⁻².

3.2. Discussion

Aquaculture systems require water plants (vegetables) that are used as biological filters in aquatic ecosystems. One of the aquatic plants that can be used for aquaponics is lettuce. Lettuce can absorb ammonia and promote oxidation with the help of oxygen and bacteria [5]. Lettuce is a filter medium that is effective for the absorption of nitrite [3].

The ANOVA test results show that aquaponics technology with different eel stocking densities showed significant differences in the eel growth (P <0.05). The highest growth rate was found in the treatment of 30 eels m⁻² and the lowest growth rate was found in the treatment of 40 eels m⁻², allegedly due to the disruption of the physiological processes of the fish due to the space not supporting the growth of the eels. Limited space for movement causes the eels to become more easily stressed. This is in accordance with the opinion of [6] which states that the stocking density will affect the competition for space. The environmental conditions will then affect growth.

The rate of survival is the percentage value of the number of live fish during the maintenance period. The results of the ANOVA test calculation shows that in the comparison between the treatments, there was a significant difference (P <0.05). The results of these observations show that in the eel aquaponics system, the stock density factor influences the life of the eels. The level of survival of the eels kept for 30 days ranged from 36% to 79%. The highest value was achieved in the treatment of 30 m⁻² eels at 79%, presumably due to the quality of the water that was still suitable, or at least still in the feasible category to support the maintenance of the eels. The lowest value in the treatment of 40 m⁻² eels was 36%, presumably due to the condition of the maintenance medium with a high stocking density. The quality of the water got worse with the increased ammonia content. The increased ammonia content related to their metabolism can cause physiological disturbances and triggers stress in the fish [7].

The stocking density factors relate to the number and weight of fish in the given area unit or volume of water. Stocking density was influenced by the number and weight of the fish, food, space and oxygen supply. Stocking fish that are too dense will slow the growth of the fish. The causes of the slowed growth of fish includes a large level of competition between individuals for food, space for movement, oxygen consumption and the amount of waste material collected in the water that can interfere with the fish. This includes carbohydrates, ammonia and nitrite [8]. Eel length measurements during the study showed that in the different lengths found in each treatment, the length increase for 20 eels m⁻² and 30 eels m⁻² involved greater length increments of 0.58 cm and 0.63 cm compared to the spread of 10 and 40 individuals m⁻² that was equal to 0.4 cm and 0.29 cm. In low stocking densities, it produces a high increase in length, while the high stocking density resulted in a low length increase. The best eel density was 30 eels m⁻² with a length of ± 17-20 cm weighing ± 5-7 grams-. This is because the stocking treatment of 30 eels m⁻² had a high weight and length increase value of 0.33 gr and 0.63 cm respectively, while the value of the percentage of life was 79%. There was also a decent water quality value to support the maintenance of the eels.
Water quality is a feasibility factor related to the ability of the water to support the life and growth of aquatic organisms [9]. The water quality measurement is important to know because it can affect the eel’s survival. Based on the research that has been done, the average temperature during the study was 29 °C; temperature affects the solubility of oxygen in the water and causes the interaction of various other factors in the context of water quality parameters. The average temperature is still tolerable for eel survival. Eels grow and live well between 25 and 32 °C [10]. Dissolved oxygen is oxygen in dissolved form in water; this is because fish cannot take oxygen in the water diffusion directly from the air [11]. The results of the measurements of the dissolved oxygen levels averaged a 4 mg L-1 reagent measurement. The ideal dissolved oxygen level in water for fish farming should not be <3 mg L-1; because this will cause the death of the aquatic organisms [12]. Dissolved oxygen for an eel, on average, should be at least 5 mg L-1 [7]. The average pH during the observation was 8. The pH value during observations was still in the optimal range until the end of the observation. This is consistent with the statement of [6], stating that the optimal pH for fish growth in aquaponics is between 7 and 8 [13].

The stocking density treatment of 40 eels m-2 had the worst water quality value out of the treatments. This causes high mortality and a low growth rate. From the results of the study, the average ammonia in all of the treatments was 0.072-0.196 mg L-1. This is still safe for the fish, because the tolerable range is <1 mg L-1. If the levels of ammonia in the water is an amount that is greater than 1 mg L-1, then pollution can be suspected [14]. Ammonia levels in the waters can cause stress in the fish and cause death, according to the statement by Rakocy et al. (2006). Ammonia in the system can inhibit growth in a stocking density of 30 m-2. This density also had the highest survival and growth rate in the aquaponics system when used With the lettuce plants [15]. This is presumably because the treatment of 30 m-tails2 had a pH > 7, so the plants absorb the organic matter dissolved in water, which causes the nitrification process to run optimally. This is in accordance with the statement of [15]; the nitrification process occurs when the aquaponics system has a pH value ranging from 7 to 9. Based on the results of this study, it can be shown that the aquaponics system with lettuce can have an effect on the survival and growth rate of eels with a water quality that is still normal.

4. Conclusion
Based on the research on the growth and survival rate in the lettuce-supported aquaponics system (Latuca sativa), it can be concluded that the difference in the density of eel stocking in the aquaponics system affects the growth and survival of the eels (Monopterus albus). The optimal stocking density that results in the best eel and lettuce growth was 30 individuals m-2.

5. References
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