The effect of different stocking densities on specific growth rate and survival rate of striped snakehead (*Channa striata*) culture in bucket system

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Abstract. Striped snakehead culture in bucket system with high stock rate at a good living environment, and also adequate feeding can lead to the maximization of production. However, if the stocking density is too high, it can inhibit the survival and growth of fish caused by competition for space, feed and oxygen as well as increased metabolic waste. The purpose of this study was to determine the effect of different stocking densities on the specific growth and survival rate of snakehead fish (*Channa striata*) in buckets. This study used is Completely Randomized Design consisting of 5 treatments and 4 replications, namely P0 (1 fish/L), P1 (2 fish/L), P2 (3 fish/L), P3 (4 fish/L) and P4 (5 fish/L). The ANOVA results showed that the difference in stocking density had a significant effect (P<0.05) on the growth rate of specific weight and length as well as the survival rate of fish. DMRT showed that P1 was the highest result for specific weight and length growth rates (0.90%/day and 0.80%/day) and the lowest at P4 (0.62%/day and 0.40%/day). In addition, the highest of survival rate are also shown at P1 (95.42%) and the lowest at P4 (32.75%).

1. Introduction
Snakehead fish (*Channa striata*) is a freshwater fish that has high economic value and high selling value. One of the reasons for this is that this fish contains a high level of albumin, which is 62.9% [3]. According to the KKP [14] the demand for snakehead fish continues to increase every year but generally, this fish supply comes from natural catches. Continuous fishing without being accompanied by restocking in nature can cause the snakehead fish population to decrease and become scarce. So it is necessary to develop the cultivation of snakehead fish (*Channa striata*).

Fish culture in buckets is a cultivation technology that is innovated from the aquaponic cultivation system, namely the integration of aquaculture and hydroponics carried out in one bucket [7]. The main principle used is to utilize aquaculture waste, especially nitrate (NO3) from the degradation of feces, leftover feed which is still rich in nutrients to grow vegetable biomass [19].

High stocking densities and supported by good environmental conditions and adequate feed can maximize production yields [22]. However, conditions of too high a density can cause competition for space, feed and oxygen for fish. Metabolic waste also becomes high so that it can be toxic to fish and inhibit the survival and growth of fish [20].
The purpose of this study was to determine the effect of different stocking densities on specific growth rates and survival rates of snakehead fish (*Channa striata*) in buckets. The benefits of this research are expected to be used as information for students and cultivators.

2. Material and methods

2.1 Research time and location

This research was carried out for 28 days, from April 10, 2021 to May 8, 2021 in Anatomy and Cultivation Laboratory of Fisheries and Marine Faculty, Airlangga University.

2.2 Tools and materials

Tools needed are bucket, plastic cup, ruler, scale, DO meter and pH meter. Then the materials are striped snakehead fish (*Channa striata*) measuring about 4-6 cm with an average weight of 1.12 g, water 60 L/bucket, feed, water spinach and charcoal.

2.3 Data analysis method

This study used a completely randomized design (CRD) consisting of 5 treatments and 4 replications, namely P0 (1 fish/L), P1 (2 fish/L), P2 (3 fish/L), P3 (4 fish/L) and P4 (5 fish/L). The container used was a bucket measuring 80 L with a volume of 60 L of water. The water spinach used was groundwater spinach (*Ipomoea reptans*) with as many as 4 stem in each glass. Charcoal is used as much as 50% of the height of the glass. Feeding was done three times a day as much as 5% of the fish biomass.

3. Result and discussion

3.1 Specific growth rate

The results of the Analysis of Variance (ANOVA) calculation showed that there was a significant difference (P<0.05) between the stocking density treatments on the specific weight growth rate and continued with Duncan’s test. The results of the average specific weight growth rate can be seen in Table 1 and specific length growth rate can be seen in Table 2.

| Treatment | Specific weight growth rate (%/day) ± SD |
|-----------|----------------------------------------|
| P0        | 0.81ab ± 0.07                          |
| P1        | 0.90a ± 0.04                           |
| P2        | 0.72b ± 0.02                           |
| P3        | 0.71b ± 0.12                           |
| P4        | 0.62c ± 0.13                           |

| Table 2. Average specific length growth rate |
|---------------------------------------------|
| Treatment          | Specific length growth rate (%/day) ± SD |
| P0                | 0.77ab ± 0.13                           |
| P1                | 0.80a ± 0.07                            |
| P2                | 0.57b ± 0.15                            |
| P3                | 0.55b ± 0.11                            |
| P4                | 0.40ab ± 0.07                           |
Based on the study, the specific weight growth rate in P0 treatment was 0.81%/day with a specific length growth rate of 0.77%/day. The increase in stocking density at P1 resulted in a higher specific growth rate than P0. The value of the specific weight growth rate at P1 was 0.90%/day with a specific length growth rate of 0.80%/day. According to Atmajaya et al. [4] fish appetite increases along with an increase in stocking density so that an increase in stocking density can also increase growth. However, the stocking density that is too high, the growth of fish cannot be optimal because it has exceeded the carrying capacity of the waters. This indicated that at P1 (2 fish/L) snakehead fish (Channa striata) were still able to grow despite an increase in stocking density.

The value of the growth rate of specific weight and length in P1 with a stocking density of 2 fish/L was the highest value of 0.90%/day and 0.80%/day compared to other treatments. The results of this study differ from those of Nguyen et al. [16] where the specific growth rate of snakehead fish (Channa striata) reared in aquaponics can reach 1.69%/day. This is presumably due to the high ammonia content in P1 which is 0.159-0.389 mg/L while according to Gaffar et al. [8] the tolerance of snakehead fish (Channa striata) to ammonia content is <0.08 mg/L. According to Norjanna et al. [17] high ammonia can inhibit fish growth. According to the KKP [13] the growth of snakehead fish (Channa striata) is relatively slow wherein the maintenance of fish measuring 3-5 cm it takes 1 month to reach a size of 5-8 cm. This is following the results of the study where the size of the fish at the beginning of the study was 4-5 cm and at the end of the study, it was between 5-6 cm.

Based on the results of the research, the growth rate of specific weight and length at P2, P3 and P4 decreased with the addition of stocking density. The decrease in the value of the growth rate of specific weight and length of snakehead fish (Channa striata) was due to an increase in stocking density in each treatment. According to Saputra et al. [21] the specific growth rate of weight and length decreased at higher stocking densities. At a high stocking density, the space for movement will be narrower. This can cause stress for fish due to strong competition for food.

According to Saputra et al. [21] conditions of stressed fish can cause hyperglycemia, which can interfere with the growth process and even fish death. Arifin et al. [2] stated that under stress conditions there is also a reallocation of metabolic energy activities such as growth and reproduction into activation energy to improve homeostases such as respiration, movement and tissue repair. In addition, Atmajaya et al. [4] also explained that the decrease in the specific growth rate was caused by the transfer of energy. In general, the energy obtained from feed will be used as maintenance energy and the remaining maintenance energy will be used as energy for growth. The stress caused by the increase in stocking density will increase the maintenance energy so that the energy that should be used for growth will be reduced.

3.2 Survival rate

The results of the Analysis of Variance (ANOVA) calculation showed that there was a significant difference (P<0.05) between the stocking density treatments on the survival rate and continued with Duncan's test. The results of the average survival rate can be seen in Table 3.

| Table 3. Average survival rate |
|--------------------------------|
| Treatment | Survival Rate (%) ± SD |
| P0 | 86.67 ± 1.36 |
| P1 | 95.42 ± 0.48 |
| P2 | 57.64 ± 3.38 |
| P3 | 34.38 ± 2.27 |
| P4 | 32.75 ± 0.83 |

The increase in the survival rate of snakehead fish (Channa striata) in treatment P1 is thought to be because snakehead fish (Channa striata) can maximize the utilization of space and feed. Although at P1 snakehead fish (Channa striata) still experience competition for space and feed, it is still within
tolerance limits resulting in a high survival rate. According to Atmajaya et al. [4] an increase in stocking density can increase the taste or response of fish to feed. This causes the energy obtained from the feed to increase so that the fish can survive and increase the survival rate of the fish. However, according to Diansari et al. [6] stocking density that is too high can also cause stress fish that occurs due to a decrease in water quality and competition for space and feed so that it can cause death and reduce survival rates. The survival rate decreased at P2 (57.64%), P3 (34.38%) and P4 (32.75%). This is presumably due to competition for space and feed. According to Hermawan [9] an increase in stocking density can affect the behavior and physiology of fish to space which can cause growth, food utilization and fish survival to decrease. According to Arianto et al. [1], stocking density that is too high can cause space competition. The narrower range of motion can put stress on fish which causes the survival of fish to decrease so that it can cause death and decrease fish survival.

According to Azhari et al. [5] one of the factors that affect the survival of fish is water quality. So it can be assumed that the decrease in survival rates in P2, P3 and P4 occurred because they had a high ammonia content compared to P0 and P1. The range of ammonia at P2 is 0.314-0.481 mg/L, P3 (0.379-0.481 mg/L) and P4 (0.454-0.609 mg/L). According to Kinne [12] ammonia that is too high can cause constriction of the gill surface resulting in a decrease in oxygen exchange, blood cell counts, oxygen levels in the blood and reduce physical endurance and endurance of fish. In addition, fish exposed to high levels of ammonia can also experience structural damage to several organs including the liver parenchyma. Damage to the liver parenchyma and blood components can quickly cause death in fish. Wahyuningsih and Gitarama [25] stated that when the ammonia content increases it will cause fish to absorb ammonia from the environment and disrupt the central nervous system which causes the fish to experience convulsions to death.

According to Nursihan [18] the survival rate of fish is classified as good if the value is 50%, moderate if the survival rate is around 30-50% and classified as bad if 30%. So that the survival rate of snakehead fish (Channa striata) at P0, P1 and P2 can be said to be good and at P3 and P4 can be said to be moderate. The highest survival rate of snakehead fish (Channa striata) during the study was aimed at P2, namely at a stocking density of 2 fish/L of 95.42%. This is following the research results of Suparmin et al. [24] where the survival rate of snakehead fish (Channa striata) reared in aquaponics can reach 95%. According to Hidayatullah et al. [10] snakehead fish (Channa striata) reared in tarpaulin ponds with a stocking density of 2 fish/L showed the best survival rate of 63.83%. This indicates that the snakehead fish (Channa striata) reared in BUDIKDAMBER with a stocking density of 2 fish/L is better than the tarpaulin pond.

3.3 Water quality

Data on the range of water quality values in the maintenance of snakehead fish (Channa striata) during the study can be seen in Table 4.

Table 4. Range water quality

| Treatment | Temperature (°C) | DO (mg/L) | pH | Amonia (mg/L) |
|-----------|-----------------|-----------|----|----------------|
| P0        | 28.1-30.2       | 0.99-2.19 | 7.4-7.8 | 0.089-0.336 |
| P1        | 28.1-30.3       | 1.00-2.08 | 7.3-7.9 | 0.159-0.389 |
| P2        | 28.2-30.3       | 0.44-2.02 | 7.6-7.9 | 0.314-0.481 |
| P3        | 28.3-30.3       | 0.30-1.81 | 7.5-8.0 | 0.379-0.481 |
| P4        | 28.3-30.2       | 0.30-1.74 | 7.5-8.2 | 0.454-0.609 |
| Tolerance | 26.8-32.5(1)   | 0.2-8.6(1) | 4-6.3(1) | <0.08(2) |

Description: (1) KKP [13], (2) Gaffar et al. [8]
According to Atmajaya et al. [4] water quality is a limiting factor for living things in the waters, biological, physical and chemical factors. Water quality beyond the tolerance limit of fish can affect the growth and survival of fish. The water quality parameters observed were temperature, dissolved oxygen (DO), pH and ammonia.

The temperature range obtained during the study was around 28.1-30.3°C. This range is included in the tolerance range of snakehead fish (Channa striata). According to KKP [13] snakehead fish (Channa striata) can live well at a temperature of 26.8-32.1°C. The lowest temperature values occurred at P0 and P1 which was 28.1°C, while the highest temperature occurred at P1, P2 and P3 which reached 30.3°C. According to Siegers et al. [23] Water temperature greatly affects fish appetite, temperatures below tolerance can reduce fish appetite while temperatures above tolerance can cause fish stress so that growth slows down.

Based on the results of the study, the highest DO value occurred at P0 which reached 2.19 mg/L, while the lowest DO value occurred at P3 and P4 which reached 0.30 mg/L. The DO range is included in the tolerance limit of snakehead fish (Channa striata). According to KKP [13] snakehead fish (Channa striata) can live and grow well at DO ranging from 0.2-8.6 mg/L. According to Listyanto and Andriyanto [15], snakehead fish (Channa striata) can survive at low DO because it has an additional breathing apparatus called a labyrinth.

The degree of acidity (pH) observed during the study ranged from 7.3 to 8.2. According to KKP [13] the pH range in the maintenance of snakehead fish (Channa striata) which is good for living and growing is between 4.4-6.1. This indicates that the pH during the study was not good for the maintenance of snakehead fish (Channa striata). The lowest pH value occurred at P1 which reached 7.3 while the highest pH occurred at P4 which reached 8.2. According to Irawan et al. [11] pH affects fish physiology such as inhibition of fish growth.

The content of ammonia obtained during the study tended to be high, ranging from 0.089-0.609 mg/L. The highest ammonia during the study occurred at P4 while the lowest ammonia occurred at P0. According to Gaffar et al. [8], the tolerance limit for ammonia in the maintenance of snakehead fish is <0.08 mg/L.

4. Conclusion
Based on the results of the research that has been carried out, it can be concluded that differences in stocking densities in the culture of snakehead fish (Channa striata) in buckets (BUDIKDAMBER) can affect the specific growth rate and survival rate of fish. The stocking density of 2 fish/L is the stocking density that has the highest specific growth rate, which is 0.90%/day at the specific weight growth rate and 0.80%/day at the specific length growth rate. The stocking density of 2 fish/L is also the stocking density that has the highest survival rate of 95.42%.

5. References
[1] Arianto D., H Harrid, I. A. Yusanti and Arumwati. 2019 Jurnal Ilmu-ilmu Perikanan dan Budidaya Perairan, 14(2): 14-20.
[2] Arifin, M. Y., E. Supriyono and Widanarni. 2014 Jurnal Kelautan Nasional, 9(2): 111-119.
[3] Asfar, M., A. B. Tawali, Pirman and M. Mahendradatta. 2019 Jurnal Agercolere, 1(1): 6-12.
[4] Atmajaya, F., Mulyadi and Sukendi. 2017. Pengaruh Padat Tebar Terhadap Pertumbuhan dan Kelulushidupan Benih Ikan Patin Siam (Pangasius hypophthalmus) Pada Sistem Akuaponik. Berkala Perikanan Terubuk, 45(2): 72-84.
[5] Azhari, A., Z. A. Muchlisin and I. Dewiyanti. 2017 Jurnal Ilmiah Mahasiswa Kelautan dan Perikanan Unsriyah, 2(1): 12-19.
[6] Diansari, R. R. V. R., E. Arini and T. Elfitasari. 2013 Journal of Aquaculture Management and Technology, 2(3):37-45.
[7] Febri, S. P., F. Alham and A. Afriani. 2019 Proceeding Seminar Nasional Politeknik Negeri Lhokseumawe, 3(1): 112-117.
[8] Gaffar, A. K., D. Muthmainnah and N. K. Suryati. 2012 Prosiding Insinas 2012, 303-306.
[9] Hermawan, T. E. S. A., A. Sudaryono and S. B. Prayitno. 2014 Journal of Aquaculture Management and Technology, 3(3): 35-42.
[10] Hidayawan, T. E. S. A., A. Sudaryono and S. B. Prayitno. 2014 Jurnal Perikanan Dan Kelautan, 20(1): 61-70.
[11] Irawan, D., S. P. Sari., E. Prasetyono and A. F. Syarif Journal of Aquatropica Asia, 4(2): 15-21.
[12] Kinne, O. 1976. Marine Ecology Volume III: Cultivation Part I. London: John Wiley and Sons. Page: 90.
[13] KKP. 2014. Ikan Gabus Haruan (Channa striata Bloch 1793) Hasil Domestikasi. Balai Perikanan Budidaya Air Tawar Mandiangin. Hal: 16-20.
[14] KKP. 2020. https://kkp.go.id/artikel/23431-langkah-kkp-kembangkan-industri-budidaya-ikan-gabus-sebagai-komoditas-unggulan-berbasis-lokal (accessed on 11/8/2020)
[15] Listyanto, N. and S. Andriyanto. 2009. Ikan Gabus (Channa striata) Manfaat Pengembangan dan Alternatif Teknik Budidayanya. Media Akuakultur, 4(1): 18-25.
[16] Nguyen, T. P. C., H. N. Nguyen. T. T. T. Thai., P. T. Tran and T. N. Nguyen. Effects of Two Hydroponic Components on Water Quality, Snakehead Fish Growth and Leaf Mustard Production in Aquaponic System. Tạp chí Nông nghiệp và Phát triển, 20(2): 27-35.
[17] Norjanna, F., E. Efendi and Q. Hasani. 2015 E-Jurnal Rekayasa dan Teknologi Budidaya Perairan, 4(1): 427-432.
[18] Nursihan, M., A. A. Damayanti and D. P. Lestari. 2020 Jurnal Perikanan 10(1): 84-91.
[19] Prayogo., Agustono., B. S. Rahardja and M. Amin. 2021 Journal of Aquaculture and Fish Health, 10(3): 373-379.
[20] Ritonga, L. B. R. 2020 Jurnal Chanos Chanos, 1(1):1-6.
[21] Saputra, A., T. Budiardi., R. Samsudin and N. D. Rahmadya. 2018 Jurnal Akuakultur Indonesia, 17(2): 104-112.
[22] Sarah, S., Widanarni and A. O. Sudrajat. 2009 Jurnal Akuakultur Indonesia, 8(2): 199-207.
[23] Siegers, W. H., Y. Prayitno and A. Sari 2019 *The Journal of Fisheries Development*, 3(2): 95-104.
[24] Suparmin., A. Setiawan., R. A. Hutagakung., F. Mudlofar and M. Taufik. 2019 *Journal of Aquaculture Development and Environment*, 2(1): 45-50.
[25] Wahyuningsih S and A M Gitarama 2020 *Jurnal Ilmiah Indonesia*, 5(2): 112-125.

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