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Nursery of bonylip barb fish *Osteochilus hasselti* in an aquaponics system

Pendederan ikan nilem *Osteochilus hasselti* dalam sistem akuaponik

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ABSTRACT

Bonylip barb fish *Osteochilus hasselti* is traditionally cultivated as a by-product in a polyculture system due to the problem of seed availability. The increase in local market demand for *O. hasselti* has not been met due to the low productivity of the growers. In an effort to increase the availability of fish seeds, intensification at the nursery stage has the potential to be effective in overcoming the limitations of land and water for cultivation. The aquaponic system can maximize yields through vertical use of space and also overcome water limitations with a recirculation system. This study aimed to evaluate the effectiveness of the aquaponics system on the intensification of *O. hasselti* nursery. The treatment tested was the stocking density of *O. hasselti* at an initial length of 4.28 ± 0.52 cm and a weight of 0.73 ± 0.29 g as many as 100 ind./m^2, 150 ind./m^2, and 200 ind./m^2 in an aquaponic system with bok choy plants (*Brassica rapa* subsp. *chinensis*). Bonylip barb fish nursery for 30 days using aquaponic system showed that the treatment resulted in maximum survival with absolute length growth, feed conversion ratio, coefficient of variation in length and weight which were not significantly different (P>0.05). At densities above 100 ind./m^2, the absolute weight growth value and the specific growth rate were higher. Overall, it can be concluded that the aquaponics system can be used for *O. hasselti* nursery at high stocking densities with the best production performance at a stocking density of 200 ind./m^2.

Keywords: fish density, growth, intensification, pak choi

ABSTRAK

Ikan nilem *Osteochilus hasselti* dibudidayakan secara tradisional sebagai produk sampingan dalam sistem polikultur karena masalah ketersediaan benih. Peningkatan permintaan pasar lokal terhadap nilem belum dapat dipenuhi karena rendahnya produktivitas pembesaran. Dalam upaya meningkatkan ketersediaan benih ikan, intensifikasi pada tahap pendederan berpotensi efektif mengatasi keterbatasan lahan dan air untuk budidaya. Perkembangan teknologi budidaya dengan sistem akuaponik dapat memaksimalkan hasil melalui pemanfaatan ruang secara vertikal dan mengatasi keterbatasan air dengan sistem resirkulasi. Penelitian ini bertujuan untuk mengevaluasi efektivitas sistem akuaponik terhadap intensifikasi pendederan ikan nilem. Perlakuan yang diuji adalah padat tebar ikan nilem dengan panjang 4,28 ± 0,52 cm dan bobot 0,73 ± 0,29 g sebanyak 100 ekor/m^2, 150 ekor/m^2, dan 200 ekor/m^2 pada sistem akuaponik dengan tanaman pak choi *Brassica rapa* subsp. *chinensis*. Pendederan nilem selama 30 hari dalam sistem akuaponik memperlihatkan bahwa perlakuan menghasilkan kelangsungan hidup serta panjang dan bobot yang tidak berbeda nyata (P>0,05). Pada kepadatan di atas 100 ekor/m^2 diperoleh nilai pertumbuhan bobot mutlak dan laju pertumbuhan spesifik yang lebih tinggi. Secara keseluruhan, dapat disimpulkan bahwa sistem akuaponik dapat digunakan untuk pendederan ikan nilem pada padat tebar yang tinggi dengan kinerja produksi terbaik pada padat tebar 200 ekor/m^2.

Kata kunci: padat tebar, pertumbuhan, intensifikasi, pak choi

INTRODUCTION

Bonylip barb (*Osteochilus hasselti*) is an endemic freshwater herbivore fish lived in rivers and swamp in Indonesia, such as Java, Kalimantan, and Sumatera. The bonylip barb population in waters is declining due to water exploitation activity and aquatic environmental changes. Bonylip barb as freshwater aquaculture commodity is undeveloped according to low seed production achievement of bonylip barb in West Java, which was only reached 54,825 individuals in 2018 (KKP, 2018). The development of local fish species need a new strategy to support seed availability continuously and to conserve the origin of fish species. The key to aquaculture development is the continuity of seed availability, yet the bonlylip barb is fish with low fecundity eggs, which only around 55,000–65,618 eggs come from a 200 g weight of brood (Syamsuri *et al*., 2017; Valentine, 2019).

The production phase of bonylip barb segmented into four stages, start from larvae production within 15 days which continued respectively by first round nursery to reach 1-3 cm fish fry in 35 days, second round nursery to reach 4-5 cm juvenile in 60 days, and third round nursery to reach 5-8 cm juvenile in the next 90 days (Jubaedah & Hermawan, 2010). The nursery period of bonylip barb is quite time consuming which causes delay in sales and profit receipt, so that the fish farmers are less interested in cultivating this fish. To enchance the seed production of the fish, intensification could be done using more controlled system which is also an effective step to overcome competition problem of land and water within aquaculture and other sectors in the future. To overcome the long period of seed production can be accompanied by co-production with faster harvest time, such as vegetables using multicrop culture method.

Aquaculture activity produces organic waste such as feces and and feed residu that can actually increase water fertility and also generate negative effects. The addition of hydroponic plant in recirculation of aquaculture system is able to reduce the compound from decomposition result of fish waste through plant roots absorptions, knowing as aquaponics system that produce fish and plants in a co-production. A co-production of fish and plants should be harmonious with each characteristic of each kind of product to balance nutrition production from fish farming and nutrition absorption from the plant. Yet, there is no specific criteria for fish and plant that is suitable to be produced in a co-production in an aquaponic system, nevertheless there is a specific indication for certain fish and plant that provide a better effect in a co-culture system (Hartami *et al*., 2015; Rini *et al*., 2018). This is expected to be able to support a better co-production for fish and plant, such as to utilize effectively the function within water and space as culture media (Rakocy *et al*., 2006), fish farming waste can be used for plant nutrition, the use of water becomes more efficient, increase the productivity, and produce two products at once (Somerville *et al*., 2014).

Some plants that can be produced in aquaponic system are water spinach *Ipomoea aquatic Forsk*, spinach *Amarantus* sp., lettuce *Lactuca sativa*, mustard green *Brassica rapa* var. *parachinensis* L (Rokhmah *et al*., 2014), and bok choy *Brassica rapa* subsp. *chinensis* (Gumelar *et al*., 2017). To increase the availability of bonylip barb seed, the intensive nursery activity should be more controlled. The intensification of bonylip barb fish farming had been done in a recirculation system with fish density of 250 ind./m^2 with 2-3 cm of average fish length and 0.31-0.35 g of average fish weight, yet the survival rate is only 55% (Setyaningrum *et al*., 2019). It is necessary to study the potential use of aquaponics system to increase the survival rate of bonylip barb fish in nursery stage as an attempt to increase the total availability of bonylip barb seed efficiently and sustainably. This study aimed to evaluate the effectiveness of the aquaponics system on the intensification of *O. hasselti* nursery.

MATERIAL AND METHODS

Experimental study and treatments

This study used a complete randomized design with three treatments and three replications. The treatments were different stocking density of bonylip barb fish, namely: 100 ind./m^2, 150 ind./m^2, and 200 ind./m^2 in an aquaponic system, reared for 30 days. The initial size of fish were 4.28 ± 0.52 cm of length and 0.73 ± 0.29 g of weight. The hydroponic plant used in this study were bok choy seedling had 1.68 ± 0.70 g of weight and 0.25 ± 0.15 g of average root weight, and total average of leaf were seven blades.

Bok choy seedlings were put into net pot contained rockwool, then were placed in a bed hole. As long as 60 cm plant bed racks were put in five stacks vertically with space of 15 cm and the total capacity were 30 net pots. Fish were stocked after bok choy cultivation, at the same day. Fish were fed three times a day with commercial feed contained 39-41% protein at 7% of fish biomass (Hermawan *et al*., 2013). During rearing time, the plants were not given any supplementary fertilizer. Meanwhile the additional water was done if the water reduced due to evaporation or the water dripping out from aquaponic system.

Design of aquaponic system

The aquaponic system used in this study consisted of three separated parts, i.e. fish rearing container, filtration unit, and plant bed racks. Fish rearing fiber container was round shaped with diameter of 1.5 m and height of 80 cm with 307 liter of water volume. The filtration unit was made from round shaped fiber container with diameter of 20 cm and height of 50 cm. Physical filtration was dacron, chemical filtration was zeolite, and bioball was used for nitrification bacteria substrate arranged in layers. All three parts of aquaponic systems were connected with a hose with diameter of 1.3 cm along 1.0 m from fish rearing container to filtration unit, and 1.0 m of hose was connected from filtration unit to bed, and 3 cm of hose along 1.0 m was connected from bed to fish rearing container.

Each unit of the aquaponic system used two pumps to supply the water from freshwater well. The water supply from fish rearing container to filtration unit used submersible pump with power of 0.034 hp and speed of 700 liter/hour, and were placed in a fish rearing container. Meanwhile, the water supply from filtration unit to plant bed rack used submersible pumps with power of 0.080 hp and speed of 3000 liter/hour. The water from plant cultivation container then entered into fish rearing container by utilizing pump thrust and gravity.

Measured parameters

The measured parameters in this study consisted of growth performance of bonylip barb fish, the growth of bok choy plants, and water quality. The growth performance of bonylip barb fish included survival rate, specific growth rate of weight, absolute weight growth, absolute length growth, feed conversion ratio, coefficient variance of length, coefficient variance of weight, and biomass. The fish measurements were done at the initial and the end of the study at total of 30 individuals per replication.

The survival rate (SR)

The survival rate of the fish was in percent (%) and calculated by this following formula:

$$SR\ (\%) = \frac{\text{Fish number at the harvest}}{\text{Initial fish number}} \times 100$$

Absolute length growth

The fish growth was calculated according to the absolute length growth by the following formula:

$$L\ (cm) = L_t - L_0$$

Note:
L_t = Final average length (cm)
L_0 = Initial average length (cm)

Absolute growth rate

The absolute growth rate of fish was counted by the following formula:

$$GR = (Wt - Wo) / t$$

Note:
GR = Absolute growth rate (g/day)
w_t = Final average weight (g)
w_o = Initial average weight (g)
t = Rearing days (day)

Specific growth rate (SGR)

The specific growth rate was counted by the following formula:

$$SGR = (Ln(Wt) - Ln(Wo)) / t$$

Note:
SGR = Daily weight growth rate (%/day)
$Ln(w_t)$ = Final average weight logarithm (g)
$Ln(w_o)$ = Initial average weight logarithm (g)
t = Rearing days (day)

Absolute weight growth

The absolute weight growth was cakculated by the following formula:

$$W\ (g) = (Wt) - Wo)$$

Note:
Wt = Final average weight (g)
Wo = Initial average weight (g)

Coefficient of variance of fish size

The variance of fish size in this study was the fish length, stated as coefficient of variance of fish size (CoV):

$$\text{CoV (\%)} = \frac{s}{y} \times 100$$

Note:
s = Standard deviation
y = Average length

Feed conversion ratio (FCR)

Feed conversion ratio was calculated by this following formula:

$$FCR = \frac{F}{Wt + D - Wo}$$

Note:
FCR = Feed conversion ratio
F = Total feed (g)
Wt = Final fish biomass (g)
D = Dead fish biomass (g)
Wo = Initial fish biomass (g)

Bok choy plant production

The plant production was measured by weighing biomass and weight. The growth of bok choy plants included total leaf and root weight.

Water quality management

The water quality management in fish container included water temperature, pH, dissolved oxygen, ammonia, nitrite, nitrate, and bacteria abundance (Table 1). The measurement of water temperature and dissolved oxygen used DO-meter, every morning at 8.00 and every evening at 17.00 WIB. The other water quality is measured once every seven days by using water test kit, except the bacteria abundance measure only at the initial and the end of the study by using total plate count method.

Bacteria abundance

The bacteria abundance in aquaponic system was calculated by using total plate count (TPC) method. The total bacteria showed in CFU/mL (colony forming unit per mL). The total plate count (CFU/mL) = (total bacteria colony × dilution factor)/ cultured plate volume.

Data analysis

The data were analyzed using one-way ANOVA program with SPSS software. When the variable showed significantly different, then Duncan test is performed to determine the best treatment.

RESULTS AND DISCUSSIONS

Results

The condition of bonylip barb fish nursery in an aquaponic system with bok choy plants showed that physical and chemical parameter of water such as water temperature, pH, and dissolved oxygen were in optimal range, meanwhile the ammonia, nitrite, and nitrate were lower than the optimal range (Table 2). There is no effect of increasing fish density on water quality.

The bacteria abundance was higher at day-30 rather than day-0 in all treatments. The denser the fish population, the more aquaculture waste, thus the bacteria abundance was increased. This showed that the bacteria role maintaining total ammonia nitrogen level during fish rearing. The aquaponic system in bonylip barb fish nursery was efective to maintain water quality in optimal condition.

The aquaculture environment during bonylip barb fish rearing with water quality as shown above resulted in a higher survival rate in all treatments, 97.78%; 99.26%; and 98.33% respectively. As the fish stocking density was increased from 100 ind./m^2 to 150 ind./m^2, the specific growth rate (SGR of weight) is increased ($P<0.05$, Figure 1b), from 2.78 ± 0.87% per day to 3.90 ± 0.08% per day. Then when the fish stocking density were added more from 150 ind./m^2 to 200 ind./m^2, the SGR of weight showed decreased into 3.34 ± 0.29% but not significantly different within other fish stocking densities ($P>0.05$). The absolute weight

Table 1. The water quality parameters.

Parameters	Measurement time	Measuring instrument
Dissolved oxygen	Daily	DO Meter
Temperature	Daily	Thermometer
pH	Weekly	pH meter
Ammonia	Weekly	Spectrophotometer
Nitrite	Weekly	Nitrite test kit
Nitrate	Weekly	Nitrate test kit
Bacteria abundance	Initial and end of study	Total plate count

growth (W) of bonylip barb fish was increasing as the the denser the fish stocking density, they were 1.00 ± 0.44 g, 1.63 ± 0.06 g, and 1.27 ± 0.18 g, respectively (Figure 1c).

The absolute weight growth at 150 ind./m^2 of fish stocking density showed significantly different than 100 ind./m^2 of fish stocking density, yet it was not significantly different compared to 200 ind./m^2 of fish stocking density. Fish that did not experience any stress could utilize feed to become an energy for their growth. Meanwhile, the absolute length growth of bonylip barb fish reared in aquaponic system for 30 days were between 0.71-1.31 cm and showed that all treatments were not significantly different (P>0.05) (Figure 1d). This meant that fish in the same length range in different fish stocking density had heavier weight.

Table 2. Water quality measurements in bonylip barb fish rearing in an aquaponic system with different fish stocking density.

Parameters	Fish stocking density (ind./m^2)			Optimal range
	100	150	200	
Water temperature (^{o}C)	26.0-28.1	26.0-28.1	26.1-28.5	24-34 (a)
pH	6.1-7.5	6.0-7.0	6.1-7.5	6.5-9 (b)
Dissolved oxygen (mg/L)	4.5-7.6	3.5-6.9	3.1-6.8	>5 (c)
Ammonia (mg/L)	0.00006-0.0015	0.00009-0.00028	0.0002-0.0020	<0.1 (d)
Nitrite (mg/L)	0.001-0.043	0.005-0.128	0.034-0.134	<1 (e)
Nitrate (mg/L)	0.988-1.252	1.237-1.578	1.075-1.654	<50 (f)
Bacteria abundance (H-0) (CFU/mL)	7.60×10^4	10.02×10^4	2.84×10^4	
Bacteria abundance (H-30) (CFU/mL)	5.20×10^7	2.16×10^8	4.30×10^9	

Note: (a) (Nurkarina, 2013); (b) (Wicaksono, 2005); (c) (Boyd, 2015); (d) (Saptarini, 2010); (e) (Losordo *et al*., 1998); (f) (Kroupova *et al*., 2005).

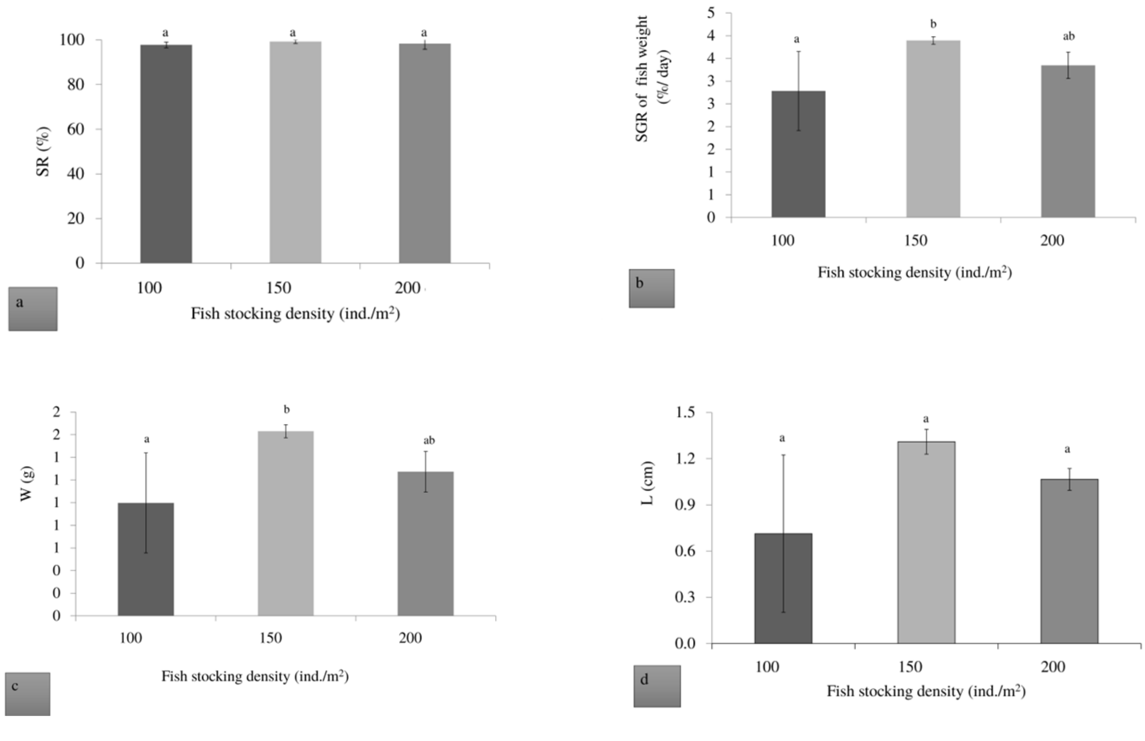

Figure 1. The growth rate of bonylip barb fish reared in aquaponic system with different fish density: (a) The survival rate (SR); (b) Specific growth rate of weight (SGR of weight); (c) Absolute weight growth (W); (d) Absolute length growth (L). The different letters at bar showed significantly different result (P<0.05).

Coefficient of variance of fish size

The coefficient of variance of fish length (Figure 2a) and fish weight (Figure 2b) at 30 days rearing were between 84-11.25% and 24.39-31.94%. According to statistic analysis, all the treatments did not significantly different among others (P>0.05) toward the coefficient of variance of fish length and fish weight.

The fish biomass at the end of the study were between 203.18-473.70 g (Figure 3) and were increased at the higher fish stocking density. The lowest fish biomass was 203.18 ± 54.51 g gained in 100 ind./m^2 of fish stocking density and statistically showed significantly different result (P<0.05) among other treatments, they were 422.61 ± 13.96 g in 150 ind./m^2 of fish stocking density and 473.70 ± 29.40 g in 200 ind./m^2 of fish stocking density. Meanwhile the fish biomass at 150 fish/m^2 and 200 fish/m^2 of fish stocking density did not significantly different (P>0.05).

Fish feed conversion ratio (FCR)

The feed conversion ratio of bonylip barb fish reared in an aquaponic system for 30 days were between 0.84-1.03 (Figure 4) and in all treatments,

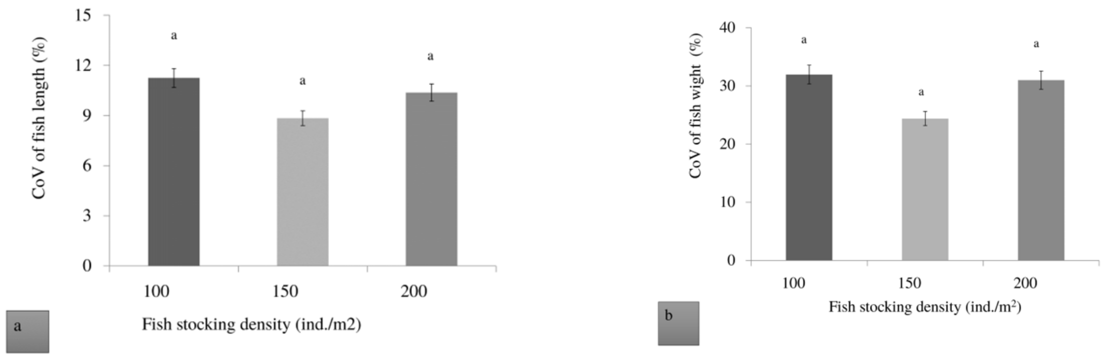

Figure 2. The coefficient of variance (CoV) of bonylip barb fish in aquaponic system with different fish stocking density: (a) the coefficient of variance of fish length; (b) the coefficient of variance of fish weight. The same letters at bar did not significantly different result (P>0.05).

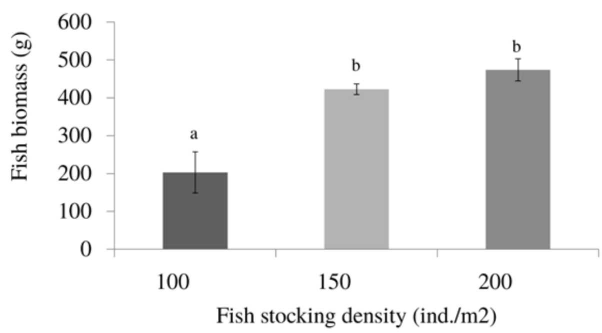

Figure 3. The fish biomass in an aquaponic system in different fish stocking density. The different letters at bar showed significantly different result (P<0.05).

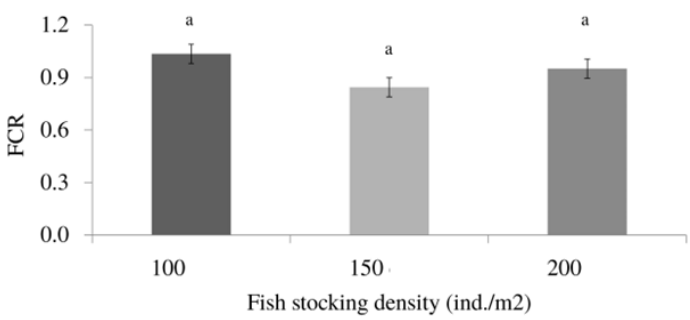

Figure 4. The feed conversion ratio (FCR) of bonylip barb fish in an aquaponic system with different fish stocking densities. The same letters at bar did not significantly different result (P>0.05).

the feed conversion ratio did not significantly different (P>0.05).

The growth of bok choy planted in an aquaponic system for 30 days was measured according to its total leaf, root weight, and plant weight. The results were not significantly different in all tested treatments (Table 3).

Discussions

Fish reared in an aquaponics system need water quality in an acceptable specific optimal range. The decrease of water quality can affect fish physiology, growth rate, feed efficiency, and furthermore, it can cause pathological changes and fish mortality in extreme conditions. In an aquaponic system, the carrying capacity is the main focus to maintain the balance between plants need and fish need in a rearing media. The carrying capacity represents fish maximum biomass in a system with acceptable specific optimal range of water quality (Yildiz *et al*., 2017a), which is determined by fish oxygen consumption level and its response toward ammonia, CO_2, and other toxic metabolic waste.

In fish nursery, the fish biomass in less due to the fish seed is still very small, therefore by the increasing of fish stocking density can increase total feed residu and fish metabolic waste for nutrition sources for plants. This study of bonylip barb fish in an aquaponics system supports intensification considering the fish survival rate was very high. The aquaponics system can also support fish welfare (Yildiz *et al*., 2017a) through water remediation, therefore the quality remains suitable for fish live through the use of plant to absorb fish waste and their feed residu. The application of aquaponics system in aquaculture is an effort to increase the water carrying capacity for increasing its productivity.

The water quality in this system is able to survive in condition that remain suitable for fish, especially the level of internal pollution that can be supressed, therefore the ammonia level and nitrite are in the range that can be tolerated by the fish during fish rearing. The increase of ammonia can occur due to increasing fish rearing time (Silaban *et al*., 2012; Wongkiew *et al*., 2017), otherwise in this experimentation, the nitrogen waste did not increase due to the increase of fish population in fish rearing media of the aquaponics system used. The bok choy in aquaponics system is able to improve the water quality so the water quality is remained suitable for bonylip barb fish culture. Wibowo and Asriyanti (2013) stated that bok choy can be used as phytoremediator to absorp organic compound and to reduce total ammonia nitrogen (TAN) in an aquaponics system, as much as 0.232 mg/L (Gumelar *et al*., 2017).

High ammonia concentration can lower the survival rate, inhibit fish growth, and cause various physiological dysfunction. The increase of bacteria abundance during fish rearing is the indicator of formation of organic substance from aquaculture internal waste that can fertilize bacteria population. There was also the increase of fish biomass due to the increase of fish stocking density inducing more total bacteria. The dissolved oxygen level in water was between 3.1-7.6 mg/L, it played a role in nitrification process therefore organic waste decomposition can occur aerobically.

A closer to optimum range of water quality that can be well tolerated by the fish can induce higher fish survival rate. The increase of fish stocking density up to 1.5 to 2.0 times showed higher survival rate, they were 97%-99% respectively, it indicated that the aquaculture environment in an aquaponic system can still be able to support bonylip barb fish live. The bonylip barb fish rearing in integrated multi trophic aquaculture (IMTA) system could induce high survival rate up to 90.29% with lower fish stocking density around 50 fish/m^2, and when the fish stocking density is increased up to 100 fish/m^2 and 150 fish/m^2, the fish mortality was higher causing lower survival rate around 53% and 22%

Table 3. The yields of bok choy plant maintained for 30 days in an aquaponic system with different fish stocking densities.

Parameters	Fish stocking density (ind./m^2)		
	100	150	200
Total leaf (blade)	20 ± 2.09[a]	21 ± 2.25[a]	18 ± 4.48[a]
Root weight (g)	7.53 ± 4.24[a]	3.40 ± 1.17[a]	4.07 ± 0.97[a]
Plant weight (g)	95.49 ± 52.12[a]	76.12 ± 53.66[a]	60.39 ± 39.24[a]
Bok choy biomass (kg)	2.9 ± 1.56[a]	2.3 ± 1.61[a]	1.8 ± 1.18[a]

Note: The same superscript at same bar did not significantly different result (P>0.05).

(Nurkarina, 2013). The IMTA system in bonylip barb fish rearing in the previous study used shell as biofilter and ornamental water plants, water spinach, and giant freshwater prawns, could produce nitrite compound between 0.007-0.256 mg/L, yet the nitrite compound level was affected the fish survival.

Compared to the IMTA system, the aquaponic system has more potential to reduce nitrite concentration. In aquaponic system perspective, the stabilization of water chemical compound usually needs no longer time, depending on its water temperature and various other factors, as a result of co-operation between bacteria and plants to maintain the water quality. The stability of water characteristic in an aquaponic system can set biological boundaries for sustainable production which can affect fish welfare conditions through complex interactions among water quality parameters (Yildiz *et al*., 2017a). As fish population increases the growth of bacteria and also the rate of decomposition of fish waste which is absorbed by plants as nutrients so that the water undergoes remediated after being polluted by organic matter originating from fish.

In the range of water quality according to their needs, fish live well as indicated by high its growth and survival. The bacteria contribution in aquaculture includes their role in stabilizing the environment quality and in fish digestive tract had been proven by many (Andriani *et al*., 2018; Mulyasari *et al*., 2016; Rurangwa & Verdegem, 2015). The microbes ecosystem is very important to water biological filtration and nutritional mineralization for plant growth therefore the function of aquaponics system can be optimal (Kasozi *et al*., 2021). The increase of bonylip barb fish stocking density in every 50 ind./m^2 increased the bacteria abundance into seven, eight, nine digits number at the end of this study, meanwhile in recirculating aquaculture system (RAS) for catfish rearing, the bacteria abundance was only reached 3×10^4 CFU/mL (Azhar *et al*., 2017).

The bacteria abundance is affected by C/N ratio in water. By the existance of organic carbon, TAN elimination can decrease substantially, the NH_4^+ is decreased up to 90% in 6 of C/N ratio (Islam *et al*., 2021). The enhancement of heterotrophic assimilation pathway inhibits nitrification process and induces lower NO_3^- production (Xu *et al*., 2016). High C/N ratio in biofilter can increase heterotrophic bacteria, then these bacteria will compete and dominate autotrophic nitrification bacteria. Therefore, managing the organic carbon level and controling dissolved oxygen level is needed to maintain the balance of bacteria population (Joyce *et al*., 2019).

In aquaponic system, the bacteria can maintain fish welfare and plant cultured. Bacteria can also induce plant growth and health through stimulation growth and biocontrol (Bulgarelli *et al*., 2015; Yildiz *et al*., 2017b). Bacteria grows in aquaponic system mostly are *Proteobacteria* and *Bacteroidetes* as two main phylum with percentage of 35% and 26%, respectively (Eck *et al*., 2019). In the increase of fish stocking density, the survival rate of fish was as higher as their growth performance, therefore the fish biomass is increased, as shown in previous study by Tawaha *et al*. (2021).

The increase of bonylip barb fish stocking density as much as 1.5 times in this study showed that the fish biomass was increased linierly, yet sloping. As the bonylips barb fish fed with formula feed containing high protein compound resulted higher fish survival rate, even though Said *et al*. (2021) stated that fish could live 100% and grow better when fish are only fed water plants rather than artificial feed. It is very likely that fish fed with formula feed accompanied by good water quality management as in aquaponics system can support more on bonylip barb fish live. The resirculation system in bonylip barb fish in natural feed based can maintain water quality in alkalinity value of 33.51 ± 0.15 mg/L, hardness of 110.86 ± 6.40 mg/L, total dissolved solid of 152.22 ± 2.34 mg/L, with ammonia concentration and low nitrite concentration were around 0.005 to 0.007 mg/L, and 0.03 to 0.06 mg/L, respectively (Syandri *et al*., 2015).

This system in a small scale is technically and financially feasible (Tokunaga *et al*., 2015) with efficient filtration and labor with aquaculture skill and appropriate aquaculture management (Benjamin *et al*., 2022). However, to produce more fish per area, the aquaponics system more promising with extra harvest comes from hydroponic vegetables. Bok choy that planted with bonylip barb fish in aquaponic system could grow into their harvest size. In fish nursery, the fish biomass in less due to the fish seed is still very small, therefore by the increasing of fish stocking density can increase total feed residu and fish metabolic waste for nutrition sources for plants.

This study of bonylip barb fish in an aquaponics system supports intensification considering the fish survival rate was very high. The aquaponics system can also support fish welfare (Yildiz *et al*., 2017a) through water remediation, therefore the quality remains suitable for fish live through the use of plant to absorb fish waste and their feed residu. The increase of fish stocking density resulted in decrease in vegetable biomass due to the plant weight and the root weight tended to get smaller even though it did not significantly different statistically. Bok choy maintenance in hydroponic system used liquid organic fertilizer in 28 days produced smaller plant weight of 40-60 g, total blade leaf of 9 to11 blades (La Sarido & Junia, 2017) rather than in an aquaponics system with bonylip barb fish.

The aquaponic system productivity is affected by the combination of fish and hydroponic plants, besides water quality. The growth of bok choy plants can be suboptimal in unsuitable environment, such as lack of sunlight (Manohar *et al*., 2018), incomplete nutrient (Chen *et al*., 2022) and the presence of heavy metals (Baroroh *et al*., 2018). For maximal growth, plants in an aquaponics system need 16 important nutrients, divided into macronutrients and micronutrients (Bittsanszky *et al*., 2016; Delaide *et al*., 2017). The optimal ratio of daily fish feed input to plant growing area will maximize the plant production while maintaining stable levels of dissolved nutrients. Fish feed provides most of the essential nutrients for optimal plant growth, except calcium (Ca), potassium (K), and ferrum (Fe), that usually insufficient and must be added into aquaponics system (Rakocy, 2007).

The addition of K fertilizer and Fe in the aquaponics system of Nile tilapia could increase the plants growth without affecting the fish growth and the survival rate (Stathopoulou *et al*., 2021). In aquaponics system, plants can cause some immediate effects for fish live. Plants are known to secrete some chemical compounds, for example through their root, to make their environment become more favorable for themselves. This phenomenon is called allelopathy (Joshi *et al*., 2020). Allelopathy plants is a plant that can secrete allelochemicals and can be very potential causing problem for fish in an aquaponics system. However, the negative effect from allelochemicals in fish had never been reported.

CONCLUSION

The aquaponics system with bok choy plant can be used for bonylip barb fish nursery intensively. The production performance of bonylip barb fish increased as the increasing of fish stocking density as the hydroponic plants performance remained constant. The aquaponics system is able to maintain water quality and increase water carrying capacity therefore it allows for fish farming at high density.

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