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The application of integrated multi-trophic aquaculture (IMTA) using floating net cages on Tilapia fish with native fish (Peres, Lemeduk, and Depik)

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ABSTRACT

Environmental problems due to aquaculture occur along with the increase in aquaculture production. IMTA is one system used as a solution in dealing with environmental problems. The objective of this study was to analyze the growth performance, survival rate, and production of the main commodity (tilapia) and the supporting commodities (Peres, Lemeduk, and Depik) which are applied through the application of integrated multi-trophic aquaculture (IMTA) using floating net cages. This research was conducted at the Lukup Badak Fish Seed Center, Central Aceh from July to August 2020. The experimental design used was a completely randomized design (CRD) with 4 treatments and 3 replications, namely: A (tilapia), B (tilapia and peres), C (tilapia and lemeduk), and D (tilapia and depik). ANOVA test results showed that the IMTA system had a significant effect on absolute length growth, absolute weight growth, specific growth rate (SGR), survival rate, and biomass production of tilapia (P<0.05). The results showed that maintenance for 42 days produced the highest value in treatment B with the increase in absolute length growth (4.26cm±0.24); absolute weight growth (5.47g±0.45), specific daily growth rate (2.28%/day±0.13) and the highest tilapia biomass production (480g/0.5m2±19.25). The highest survival rate was found in treatment C (82.42%±2.28). It was concluded that the treatment using the IMTA system was better than without the IMTA system.

Introduction

Tilapia *(Oreochromis niloticus)* is a fishery commodity that has economic value and potential in aquaculture because it is able to adapt to environmental conditions with a wide range of salinity (Aliyas, *et al.,* 2016). Red tilapia has several advantages compared to other freshwater fish. These advantages are fast growth, easy to breed, willingness to eat all food ingredients (omnivores), wide adaptability and high tolerance to environmental conditions (Suwoyo *et al.,* 2018; Iskandar *et al.,* 2021).

Fish cultivation using floating net cages is commonly found in Laut Tawar Lake, Aceh. Most of the fish cultivated here are tilapia (*Oreochromis niloticus).* According to Sambu and Amir (2017) the use of floating net cages for tilapia in lakes and reservoirs were widely developed as a source of freshwater fish production. However, aquaculture system using floating net cages is one of the causes of aquatic environment degradation.

The floating net cage cultivation system can cause various negative impacts on the aquatic environment. According to Siagian (2010), several impacts that arise include overfeeding, which may reach 10% of fish body weight, resulting in the load of organic waste derived from feed residue and feces. Putra *et al.* (2015) added, the negative impacts from overfeeding are in the form of sedimentation, backfill and eutrophication which can reduce water quality.

One of the efforts that can be done to overcome water quality problems is through the use of Integrated Multi-trophic Aquaculture (IMTA)

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approach. Troell *et al.* (2009) stated that the IMTA concept is the rearing of a combination of several species from different trophic levels, namely between aquaculture organisms that are fed using feed (fish) with aquaculture organisms that absorb inorganic matter (seaweed), and aquaculture organisms that absorb organic matter (suspension and deposit feeders, e.g. shellfish).

The selection of commodities that can be used in the IMTA system is very wide. The selected commodities are adapted to their ecosystem function and have high economic value. Selection of the right aquaculture species in the IMTA system can reduce organic and inorganic phosphate, carbon, and nitrogen content (Chopin *et al.,* 2010; Yuniarsih *et al.,* 2014). Peres (*Osteochillus kappeni*), lemeduk (*Barbonymus Schwanenfeldii*) and depik (*Rasbora tawarensis*) are fish natively found in Laut Tawar Lake which have high economic value. Peres fish are herbivores that eat plankton, periphyton and various types of aquatic plants (Wicaksono, 2005), while the lemeduk fish are omnivorous (Gunawan *et al.,* 2017), and the depik fish eats plankton (Muchlisin *et al.,* 2015) and insects as their main diet (Hasri and Rosa, 2012).

Several studies on the IMTA system have been carried out, including the growth performance of tiger prawns (*Penaeus monodon*) and green mussels (*Perna viridis*) with the IMTA system (Evania *et al.,* 2018), lobster cultivation (*Panulirus homarus*) and abalone (*Haliotis* sp.) with an integrated system (Setyowati *et al.,* 2013), the effect of different tiger shrimp densities on the IMTA concept (Dewi *et al.,* 2020) and the growth rate of abalone (*Haliotis squamata*) through IMTA cultivation (Hayati *et al.,* 2018). These researches are used as the basis for developing tilapia cultivation with native fish as supporting commodities based on IMTA, with the aim to increase aquaculture productivity without damaging the aquatic environment. Therefore, this study aims to analyze the growth performance, survival rate, and production of main commodities (tilapia) and supporting commodities (Peres, Lemeduk, and Depik) which are implemented through the application of integrated multi-trophic aquaculture (IMTA) using floating net cages.

Materials and Methods
Location and time of research
This research was conducted from July to August 2020, at the Fish Seed Center (BBI) UPTD in Lukup Badak Takengon, Central Aceh Regency.

Experimental design
This study used a completely randomized design (CRD), consisting of four treatments and three replications. The design refers to the research conducted by Yuliati *et al.* (2005) that found the best stocking density for tilapia seed to be 100-200 fish/m^2, and the research conducted by Nurfadillah *et al.* (2021) that found the best total biomass production to be the combination treatment of 112 individuals of tilapia and 38 individuals of lemeduk. According to Hasri and Ahmadina (2016) the best stocking density of tilapia fish is 75 fish/m^2 in the soil pond happa system, and in the study of Moniruzzaman *et al.* (2015) the best stocking density of Thai Silver Barb (*B. gonionotus*) in floating net cages is 30 fish/m^3. Based on these references, the treatment given is as follows: Treatment A/control (Tilapia 110 fish/m^2); Treatment B (110 fish/m^2 of Tilapia and 40 fish/m^2 of Peres); Treatment C (Tilapia 110 fish/m^2 and 40 fish/m^2 of Lemeduk); Treatment D (Tilapia 110 fish/m^2 and 40 fish/m^2 of Depik).

Preparation of containers, fish and feed
This experiment was carried out on a multilevel net where the outer net was happa with a size of 2x2 m and an inner net with a size of 1x1 m. The illustration of the net is presented in Figure 1. Fish seeds were obtained from BBI Lukup Badak, Central Aceh with an average length of 1-3 cm. The feed given is commercial feed in the form of floating pellets measuring 0.5-0.9 mm with a protein content of 35% with a feeding rate of 8% of fish. The frequency of feeding was 2 times a day on 8 am and 5 pm.
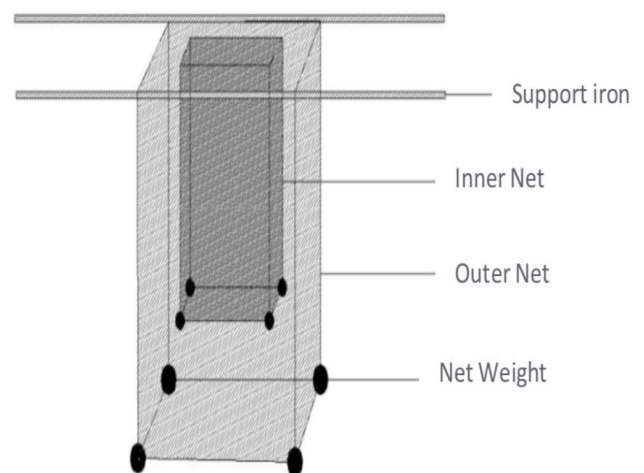

Figure 1. The illustration of the net.

Research Parameter
Absolute length growth

The absolute length growth was calculated as follow Nurfadillah *et al.* (2021):

$$L = Lt - Lo$$

Information:
L = Length growth (cm)
Lt = Average length at final experiment (cm)
Lo = Average length at initial experiment (cm)

Absolute weight growth

Absolute weight growth is calculated using the Effendie (2004) formula:

$$W = Wt - Wo$$

Information:
W = Weight growth (g)
Wt = Average weight at final experiment(g)
Wo = Average weight at initial experiment(g)

Specific growth rate (SGR)

Specific growth rate (SGR) was calculated using the formula from Zonneveld *et al.* (1991):

$$SGR(\%/days) = \frac{(Ln\ Wt - Ln\ Wo)}{t} x100\%$$

Information:
SGR = Specific daily growth rate (%/day)
Wt = body weight of fish at the end of experiment (g)
Wo = body weight of fish at the beginning of experiment (g)
t = duration of experiment (days)

Survival rate

The calculation of the survival rate is based on the formula of Muchlisin *et al.* (2016), namely:

$$SR = \frac{Nt}{No} x\ 100\%$$

Information:
SR = Survival rate (%)
Nt = total fish at the end of experiment (fish)
No = total fish at the start of experiment (fish)

Fish biomass production

The rate of biomass production can be calculated using the formula Zonneveld *et al.* (1991):

$$BM = Wt\ x\ Nt$$

Information:
BM = Biomass Production (g/0.5m²)
Wt = Total weight of fish in container experiment (g)
Nt = Total number of fish at the end of the experiment (fish)

Analysis data

The data were subjected to the one-way analysis of variant (one-way ANOVA) test and followed by Least Significant Difference tests (LSD) and Honestly Significant Difference test (HSD) test using the SPSS program.

Results

Results from the ANOVA test showed that the parameters of absolute length growth, absolute weight growth, specific growth rate (SGR), tilapia biomass production, and tilapia survival had a significant effect on IMTA polyculture system (P<0.05) (Table 1).

The highest absolute length growth of tilapia was found in treatment B (4.26 cm ± 0.24) and the lowest was found in treatment A (3.45 cm ± 0.07). The LSD test results showed that the effect of treatment B on tilapia was significantly different from treatment A and C, but not significantly different from treatment D. Furthermore, the highest absolute weight growth of tilapia was found in treatment B (5.47g±0.45) and the lowest was in treatment A (3.86g±0.35). The LSD test results showed that treatments B and D were not significantly different from C but significantly different from treatment A. Similarly, the highest specific growth rate (SGR) of tilapia was found in treatment B (2.28%/day ±0.13) and the lowest was in treatment A (1.96%/day±0.04). The results of the HSD test showed that treatment B was significantly different from treatment A but not significantly different from treatments C and D.

The average survival rate of tilapia was highest in treatment C (82.42%±2.28) and the lowest in treatment A (62.72%±8.99). The LSD test results showed that treatment C was significantly different from A but not significantly different from B and D treatment. Whereas the production of tilapia biomass showed that out of each treatment, production was highest in treatment B (480.25g/0.5m²±19.25) and the lowest was in treatment A (289.65g/0.5m²±70.91). The LSD test results showed that treatments B, C, D were not significantly different from each other but significantly different from treatment A.

The results of observations on the performance growth of native fish (Peres, Lemeduk and Depik) in the IMTA system showed that their growth in length and weight increased with time. The highest absolute length growth was in peres fish (2.83cm±0.15) then lemeduk fish (1.08cm±0.36) and the lowest was depik fish (1.03cm±0.08) (Figure 1). The growth of absolute weight was also highest in peres fish (6.94g±0.26) followed by lemeduk fish (0.52g±0.21) and depik fish (0.41g±0.05).

Water quality parameters observed in this study include temperature and pH. The measurement results show that the average water temperature value is 23.7 °C and the average water pH value during the study is 7. The water quality parameters during maintenance are still within the optimal range for fish growth.

Discussion

Growth is a change in length and weight in a certain period of time. The absolute length growth, absolute weight growth, and specific growth rate of tilapia with native fish (peres, lemeduk, depik) in the IMTA system showed that the IMTA system treatment was better than the system without IMTA. This is because the remnants from tilapia metabolism in IMTA systems that are maintained in the inner net can be utilized by the fish in the outer net. This is in accordance with the statement of Yuniarsih *et al.* (2014) and Irisarri *et al.* (2015) that the IMTA system provides an additional function to the aquatic environment in reducing water pollution caused by aquaculture waste, namely the utilization of the waste by other commodities as species that absorbs organic and inorganic materials. Fish growth is influenced by several factors, namely internal and external factors. Internal factors include genetics, disease resistance and ability to utilize food, whereas external factors include physical, chemical and biological characteristics of the water environment (Hidayat *et al.,* 2013).

Growth will occur when the energy needs for metabolism and maintenance of body tissues have been met in accordance with the needs of the fish (Hepher, 1988, Yuvaraj *et al.,* 2015).

The growth of tilapia is good because the feed provided contains protein in accordance with the body's needs for both energy and growth (Djajasewaka 1985; De silva and Anderson, 1995; Samidjan *et al.,* 2016). In the IMTA system, native fish are able to act as species that absorb metabolic byproducts from the main commodity and feed on natural food. This is in accordance with the statement of Samsudin *et al.* (2010) that nilem fish have the ability to utilize periphyton as natural food and are able to utilize several types of plants, mosses and algae as food sources. Rumondang (2013) states that Brek fish (*Barbonymus balleroides*) is an omnivorous fish that tends to be herbivorous with their main food being phytoplankton, followed by gastropods, crustaceans, fish, insects, aquatic plants, and detritus. Hasri and Rosa (2012) stated that depik fish are fish that utilize insects and phytoplankton.

Table 1. Results of measurement of absolute length growth, absolute weight growth, specific growth rate (SGR), survival rate and fish biomass production.

Treatment	Research Parameters				
	Absolute Length Growth (cm)	Absolute Weight Growth (g)	SGR (%/day)	Survival rate (%)	Tilapia biomass production (g/0.5m²)
A (Tilapia)	3.45±0.07[a]	3.86±0.35[a]	1.96 ±0.04[a]	62.72±8.99[a]	289.65±70.91[a]
B (Tilapia+Peres)	4.26±0.24[b]	5.47±0.45[b]	2.28±0.13[b]	76.36±6.55[ab]	480.25±19.25[b]
C (Tilapia+Lemeduk)	3.65±0.14[a]	4.61±0.09[ab]	2.00±0.06[ab]	82.42±2.28[b]	464.08±27.52[b]
D (Tilapia + Depik)	3.70±0.24[ab]	4.86±0.30[b]	2.03±0.10[ab]	77.87±6.05[ab]	437.38±45.56[b]

Note: Different superscript letters in the same column show significant differences (P<0.05).
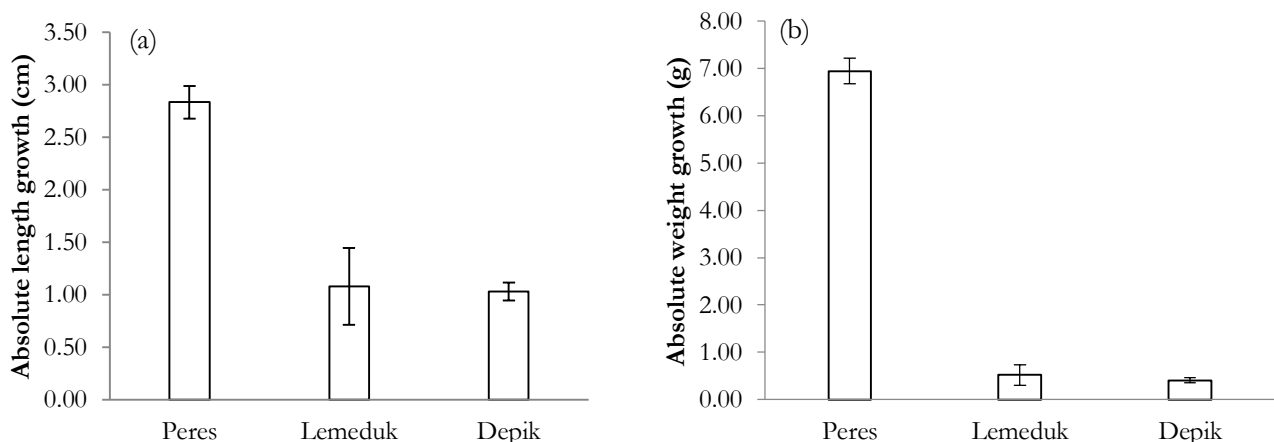

Figure 1. Growth performance of Native fish in IMTA system (a) absolute length growth and (b) absolute weight growth of peres, lemeduk, depik fish.

Tilapia biomass production in the IMTA system was higher than the system without IMTA. The combination of rearing tilapia with peres, lemeduk and depik fish can increase the production of tilapia biomass. This is because maintenance with the IMTA system can reduce feed waste, allowing it to maintain the water quality stability of the aquaculture system. In addition, the IMTA system can play a role in maintaining the availability of nutrients in the waters due to the interaction between the main commodity (tilapia) and supporting commodities (Peres, Lemeduk, and Depik) in the process of utilizing nutrients. The selection of fish commodities in the IMTA system is very important in accordance with their ecological functions in the ecosystem, as well as the selection of commodities with important economic value. Therefore, the IMTA system can function well in trophic interactions through the mutual use of nutrients, which keeps the water quality stable and allowing cultivated commodities to grow and live well (Irrisari *et al.* 2015; Putro *et al.* 2015; Silva *et al.* 2015). Referring to Saimima *et al.,* (2020), the growth rate of baranong fish with the IMTA system was higher than without IMTA. Research by Radiarta and Erlania (2016) regarding the IMTA system in Grubuk Bay, Lombok, also showed that the specific growth rate of cultured organisms to be 2.17-2.63% per day.

Conclusion

The application of floating net cage cultivation using the IMTA system for tilapia with native fish (peres, lemeduk and depik) resulted in a higher growth performance and total production when compared to the system without IMTA. The highest growth performance and total biomass production was found in treatment B (combination of tilapia and peres).

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