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Selecting Fish Combination of Polyculture to Reduce Periphyton Abundance in Floating Net Cage in Cirata Reservoir, West Java, Indonesia

Zahidah Hasan, Y. Setiawan, and E. Rochima

Faculty of Fisheries and Marine Science, Universitas Padjadjaran, Kampus UNPAD Jl. Raya Bandung Sumedang Km 21, Jatinangor 40600, Bandung, Indonesia

Abstract

Being a considerable potential area for aquaculture activities in the form of floating net cage, reservoir has taken on issues due to its characteristics as a common property with an open access. The problems have led to the vast growing and uncontrolled number of the net cages; one of which occurs in Cirata Reservoir. The objective of this research was to find the best combination of fishes in polyculture at Floating net cage in order to reduce periphyton abundance and to increase aquaculture productivity in Cirata Reservoir. The research has been conducted from February to March 2015. The research method used completely randomized design with three treatments and three replications. The treatments consist of fish combination of tilapia with silver barb, carp with silver barb, and black pacu with silver barb which were cultured for five weeks in floating net cage size (1 × 1 × 1) m^3. The individual fish weight were approximately 10 g for tilapia, carp and silver barb, and approximately 4 g for black pacu. stocking density were 80 fishes per unit cage (40 fishes for each species). The combination of black pacu and silver barb produced highest productivity of 459.77 gr / m^3 or 82% during five weeks. Meanwhile, combination of carp and silver barb gave lowest periphyton abundance of 28 345 cells / cm^2. It can be concluded that black pacu and silver barb is the best combination due to growth rate and aquaculture productivity but not in periphyton abundance.

Keywords: Polyculture, Cirata reservoir, Cageculture.

Corresponding Author:
Zahidah Hasan
ibuzah@gmail.com

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1. Introduction

Being a considerable potential area for aquaculture activities in the form of floating net cage, reservoir has taken on issues due to its characteristics as a common property with an open access. The problems have led to the vast growing and uncontrolled number of the net cages; one of which occurs in Cirata Reservoir. Operating with its common purpose, floating net cages in Cirata Reservoir has been developed as a habitat for several types of freshwater fish, such as carp (*Cyprinus carpio*) as the main species, Nile tilapias (*Oreochromis niloticus*), panga catfish (*Pangasius sutchi*), and black pacu (*Colossoma macropomum*). Those types of fish rely on their feeding from artificial feeds, and to enhance their growth to improve their quality, they are often overfed [1, 2]. Feeding Excessive feeding and the metabolic waste of cultured fish would pose a problem for the environment that leads to another problem for the ecosystem in the case of the organic waste (particularly that contains nitrogen and phosphor). Such condition has triggered eutrophication and declining water quality which has negative impacts on the aquaculture activities themselves. One of the negative impacts of the eutrophication may be in the form of organic waste produced from the activities. This waste would be decomposed to become inorganic nutrients that may cause the expanding number of periphyton growing attached to the walls of floating net cages. This ecosystem phenomenon would gradually undermine the nets.

The unmanageable increasing number of floating net cages is one of the causes of decreasing water quality faster than the ability of the water body to perform self-purification. Based on this appearing ecosystem phenomenon, therefore, we conduct this research with the purpose of formulating an eco-friendly farming system in order to reduce pollution caused by the farming activities; the system is trophic level based polyculture system. Polyculture system convinced better than monoculture to reduce negative effect of aquaculture [3]. Monoculture in pellet-fed ponds as pond water readily becomes eutrophic which stresses the fish. An 80:20 system of stocking fish with 80% of the biomass at harvest comprising the target species, and the remaining 20% of the biomass, "service fish" such as silver carp to feed on the phytoplankton produced by fish metabolic wastes [4]. Although silver carp has a relatively low value compared to target fish such as crucian carp and tilapia, the improvement in water quality leads to a better food conversion ratio, less disease, reduction or elimination of the need for chemicals and drugs. In polyculture system, the types of fish are selected based on their feeding habits so that the farmers may use the feeds as efficiently as possible to minimize uneaten feed in the farming media. Such farming system may, indeed, decrease the pollution produced from uneaten feed and metabolism residues, as well as the number of periphyton attached to the nets that may extend the using time of the nets. Silver barb (*Osteochilus hasselti*) is one of the types with low tropic level and feeds on periphyton so they can be integrated with carp, Nile tilapia, and black pacu as the main cultured fishes in Cirata Reservoir. In addition to feed efficiency, trophic level based aquaculture will also function as a natural water cleaner [5]. In Maninjau Lake, Siver bars could be used as water cleaner [6].

In term of productivity several research reported that polyculture more productive than monoculture. Polyculture between prawn and milkfish productivity was highly significant (923.50 kg/ha/crop) than monoculture (536.22 kg/ha/crop) [7]. Meanwhile in Bangladesh, polyculture between silver barb and carp production was significantly higher (2002.45 kg/ha/5 months) than silver barb in monoculture system

(1556 kg/ha/5 months). Net benefit of polyculture 1.13 times compare to monoculture ones [8]. In Mexico, simulated NPV of monoculture of tilapia, polyculture with crayfish in medium density and polyculture with crayfish in high density were $4,855.06, $7,923.33 and $1,519.88 respectively [9].

2. Methods

Research is conducted from February 23 to March 31, 2015 in Cirata Reservoir, Maleber Block, Cikalong Kulon District, Cianjur Regency, West Java. The method used for the purposes of this research is experimental one with completely randomized design consisting of three treatments with three replications in the following experimental units:

A = cage size (1 × 1 × 1) m^3 containing Nile tilapias and sliver barb with stocking density for each type of fish 40 fish.

B = cage size (1 × 1 × 1) m^3 containing carps and silver barb with stocking density for each type of fish 40 fish.

C= cage size (1 × 1 × 1) m^3 containing black pacu and silver barb with stocking density for each type of fish 40 fish

The tested organisms used for this research include seeds of silver barb, black pacu, Nile tilapias, and carps from fish farmers in Cirata Reservoir. Fish weigh 10 grams/fish for carps, Nile tilapias, and sliver barb and 4 grams/fish for black pacu. The black pacu weigh lighter than the other fish considering that this species has the tendency to become carnivorous and may attack those with the similar size. Before being transferred to the experiment media, the seeds are acclimated for one day without feeding. The acclimated fish are then spread in the media in the morning to avoid stress on the fish. The tested fish are farmed for five weeks and during the farming are fed two times a day at 8 a.m. and 4 p.m. The feed is 5% of the fish's biomass and in the same type of commercial feed contain 28% of protein for every treatment.

The measured parameters consist of quantitative parameters that include absolute weight growth, aquaculture productivity, the abundance of periphyton, and water quality that includes dissolved oxygen, ammonia, acidity level (pH), and temperature. All parameter measured every week except aquaculture productivity at the end of the study.

The absolute weight growth is measured with Effendi's (1997) formula as follows:
$W = Wt - Wo$
Where:

W = absolute weight increase (g)

Wt = final weight (g)

Wo = initial weight (g)

Aquaculture productivity is calculated at the end of the study with the following formula:

$$P = \frac{Wt - Wo}{l \times w \times h}$$

Where:

P = aquaculture productivity (kg / m3)

Wt = final weight (g)

Wo = initial weight (g)

h = height of cage (m)

w = width of the cage (m)

l = length of cage (m)

Observation on the sampling periphyton is conducted once a week in sampling nets which size 5×5 cm^2 for each treatment. Sampling periphyton are picked up by scraping and transfering to the sampling bottles which are added water for 30 millilitres and 1-2 drops of formalin 10%. After that the samples are transferred to the counting chamber covered with object glass and observed under the microscope.

The abundance of periphyton are measured using formula as follows:

$$N = (n \times At \times Vt)/(Ac \times Vs \times As)$$

Where :

N = periphyton abundance (cells / cm2)

n = number periphyton observed (cell)

As = area of the cages scraped (cm2)

At = surface area of the cover glass (cm2)

Ac = observed area (cm2)

Vt = volume of sample bottles (30 ml)

Vs = observed volume (ml)

Data containing aquaculture productivity, absolute weight growth, and abundance of periphyton from the research are analyzed using ANOVA. Should any significant difference occur, further test using Duncan test is then selected considering its 95% level of reliability in order to notice the difference among the treatments [10].

3. Results and Discussion

The results from analysis of variance in the research on polyculture system for five weeks followed by Duncan test show that each treatment combination demonstrates different weekly weight growth (Figure 1.) and absolute weight increase (Table 1).

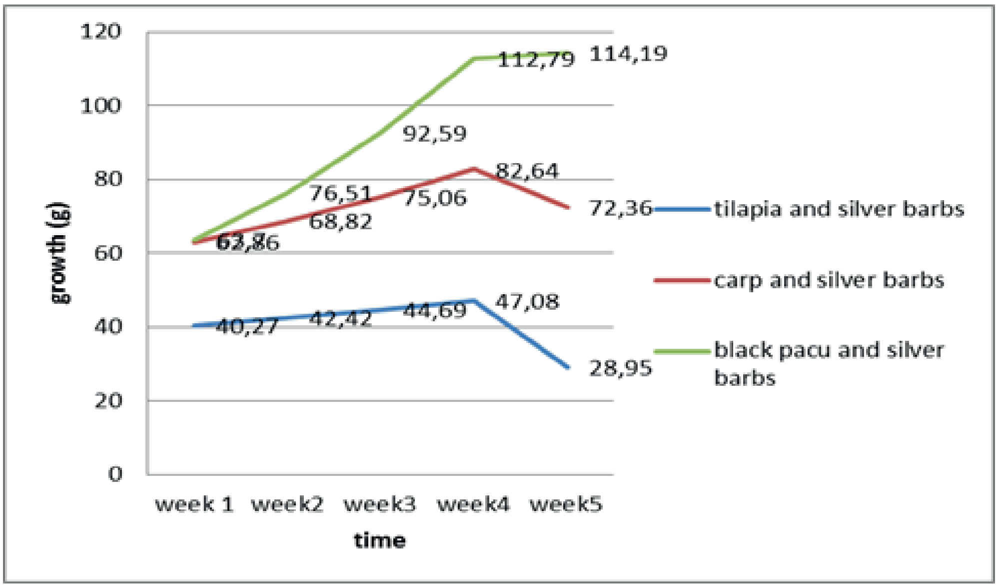

Figure 1: Weekly growth.

Table 1: Absolute weight increase during research.

Fish combination	Initial weight (g)	Final weight (g)	Absolute weight increase (g)	Percentage (%)
Tilapia	400	527,4	127,4	
Silver barb	400	476	76	
Total	800	1003,4	203,4	25
Carp	400	672	272	
Silver barb	400	488,7	88,7	
Total	800	1160,7	360,7	45
Black pacu	160	514,8	354,8	
Silver barb	400	505	105	
Total	560	1019,8	459,8	82

It is pictured in the Figure 1 that the combination of black pacu and silver barb shows the highest weight growth, while the combination of Nile tilapias and silver barb show the lowest weight growth. The same figure also reveals that weight growth increases until week four, however, in the fifth week deceleration occurs on the combination of black pacu and silver barb and decrease on the other two combinations. It is suggested that the system have reached the limit of spatial carrying capacity. The increasing biomass is followed by decreasing growth level that in the certain level of biomass the growth will stop because they have reached the spatial carrying capacity (environmental support). Increasing level of biomass is inevitably followed by the increasing amount of feed, metabolism waste, oxygen consumption, and decreasing water quality [11].

It is shown in Table 1 that the highest absolute weight growth at the end of the research occurs on black pacu. The cause is believed to be the fact that black pacu are omnivorous, highly grazed with high level of growth and tolerance to the poor ecosystem [12]. Based on such character, black pacu consume the feed pellet best, while the uneaten feed and attached periphyton in the nets are immediately consumed by the silver barb as the additional fish which is herbivorous. On the other hand, the combination of silver barb and Nile tilapias shows the lowest absolute weight gain because these types of fish have the same characteristics and niche leading to a competition in the ecosystem that they cannot consume the feed optimally.

The number of periphyton in the media is influenced by the farmed species. Silver barb are the type of fish with low tropic level with the high level of periphyton consuming that the attached periphyton is eaten and the nets become clean. In such condition, the carps farmed in the same place do not become a competitor for the silver barb in consuming periphyton. In the context of symbiosis, silver barb also consume the remaining waste from carps; therefore, the waste release to the water or reservoir may be reduced in order to reduce eutrophication.

Based on the fish combination, absolute weight gain of silver barb with carp, black pacu, and Nile tilapia, it is discovered that the highest number is for those kept with black pacu (105 grams), followed by carps (88.7 grams), and Nile tilapias (76.0 grams). It indicates that black pacu possess the different characteristics and niche with silver barb that the fish do not compete with the black pacu in consuming periphyton.

The abundance of periphyton is observed every week. In the beginning of the cage installation, periphyton attached to the nets have not appear yet. On observation week 1, periphyton starts to grow because of the nutrients in the water from the uneaten feed, and it is also supported by the adequate intensity of sunlight around the water. During the research period, the abundance of periphyton shows fluctuation as described in Figure 2. However, the most distinctive decrease in the polyculture combination of carps and silver barb as the indication that periphyton is consumed by the silver barb as organic feed. The condition of the nets on the last week of observation is shown in Figure 3.

The results from the experiment of polyculture with combination of carps and silver barb indicate that the abundance of the lowest periphyton average is 28346 sel/cm^2 in five weeks of farming. Water quality is an external factor that can affect the growth rate. It is cause by the different levels of tolerance of every type of fish for dissolved oxygen, temperature, and pH. Among those parameters, oxygen is limited factor in aquaculture especially in Cirata reservoir as eutrophic waters. Fish, as well as other living creatures, need oxygen for metabolism to support their activities, growth, reproduction, and others. Oxygen is converted into energy for metabolism to support fish's activities, such as swimming, growing, and reproducing [13, 14]. Therefore, the oxygen affect all activities of the fish, food conversion, as well as the rate of growth depends on the oxygen [15–17]. In Cirata Reservoir tilapia reared with aeration treatment growth

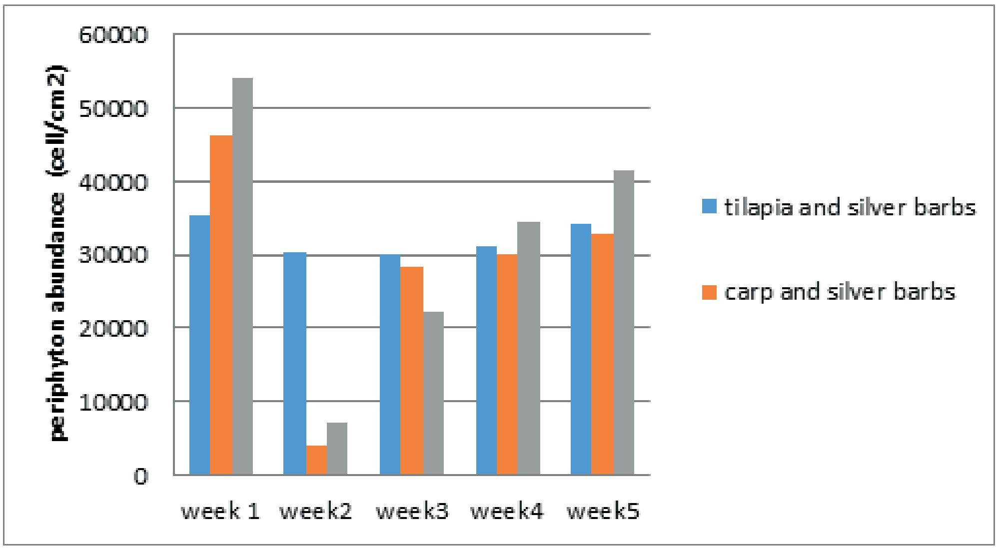

Figure 2: Periphyton Fluctuation.

Tilapia+silver barb | Carp + silver barb | Black Pacu + silver barb

Figure 3: Net cage condition at the end of the research.

495% meanwhile not aerated ones growth only 130% after 35 cultured days [19]. Table 3 shows that water quality parameters of water quality in the range of optimal except dissolved oxygen.

It is important for those farming in floating net cage to notice several crucial aspects. The first one is the absolute weight growth or the biological aspect as discovered in this research. The second one is in the terms of ecology; it is of great consequence that fish farming activities should regard the impacts of the activities to the environment. In general, the challenges for farming in floating net cages relate to improvement of nutrients in the water from the uneaten feed and fish excrement, as well as impacts

Table 2: Water quality range during research.

Fish combination	Temperature (°C)	pH	DO (mg/L)	Ammonia (mg/L)
Tilapia- Silver barb	28. 5-29.4	6.76-7.06	4.18-5.26	0-0.004
Carp- Silver barb	28.5-29.4	6.8-7.06	4.22-5.39	0-0.005
Black pacu- Silver barb	28.5-29.4	6.79-7.06	4.14-5.2	0-0.005
Reference	deviation 3	6.5-9.0	≥5	0.2

Table 3: Comparison of three important aspects.

Fish combination	Indicator			
	Biological	Ecological		Economical
	Growth	Periphyton abundance	Water quality	productivity
Tilapia- Silver barb	✓	✓✓✓	✓✓	✓
Carp- Silver barb	✓✓	✓✓✓	✓✓	✓✓
Black pacu- Silver barb	✓✓✓	✓✓	✓✓	✓✓✓
Noted: ✓✓✓: Good ✓✓: Less ✓: Worse				

to the water quality, environment, and health in the ecosystem [20, 21], and in this research, the ecological aspects are observed from the water quality and the abundance of periphyton. The third one is the economic aspects related to the farming productivity. Table 4 shows the comparison among the three aspects in this research.

From the Table 4, it can be seen that each combination of farmed fish possesses its own strengths and weaknesses. The biological and economic aspects indicate that the combination of black pacu and silver barb is more superior than the other treatments, while the water quality and the abundance of periphyton show that the combination of Nile tilapias and silver barb has the same ecological value as the combination of carps and silver barb.

In the polyculture system, the combination of black pacu and silver barb farmed for five weeks produces the highest average absolute weight growth which is 91.96 grams and the highest farming productivity of 459.77 grams/m^3or equal to 82%. Meanwhile, the other two combinations produce nearly the same abundance of periphyton.

4. Conclusions and Recommendations

Therefore, based on the results from the experiments, it can be concluded that even though the combination of black pacu and silver bars produces the highest values for the biological and economic aspects, it is alarming for the ecological aspects as the pacu naturally tend to be more aggressive and cannibalistic that they may break their nets and those around them. It is, thus, suggested that the combination of carps and silver bars is more recommended to be farmed in polyculture system in Cirata Reservoir.

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