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Sustainable aquaculture development in floating nets at Cirata reservoir (West Java, Indonesia) through single sex nilem fish introduction

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Abstract. *Yustiati A, Andriani Y, Herawati T. 2017. Sustainable aquaculture development in floating nets at Cirata reservoir (West Java, Indonesia) through single sex nilem fish introduction. Asian J Agric 1: 29-34.* This research aimed to develop a sustainable aquaculture system using single-sex nilem fish (*Osteochilus hasseltii* Valenciennes, 1842; syn. *Osteochilus vittatus* Valenciennes, 1842) in trophic level-based farming and to analyze the feeding habits, types of meal and preference level of the feed in *O. vittatus* farmed in Cirata Reservoir. In addition, it also aimed to determine the fish's ability as a biocontrol agent for water cleaning by measuring the ability to utilize periphyton attached to the floating nets. Research was conducted at the Laboratory of Ciparanje, Faculty of Fisheries and Marine Sciences, Universitas Padjadjaran and floating nets of Cirata reservoir. Observations of the performance of biological testing and food feeding were applied with the experimental design method of Completely Randomized Design (CRD) consisting of 5 treatments and 3 replications. The five treatments include non-artificial feeding (treatment A), 1% feeding of body weight per day (treatment B), 2% feeding of body weight per day (treatment C), 3% of feeding of body weight per day (treatment D), and 4% feeding of body weight per day (treatment E). The results showed there was no difference in both the survival and growth levels of the female single-sex fish that were given both commercial and non-commercial feed. The highest feed efficiency was observed in the 3% of commercial feeding treatment, amounting to 55.30%. The fish are herbivorous and generalist with trophic levels between 1.03% and 1.45% eating plankton for living. Fish fed with artificial food to 4% of the biomass still grazed on phytoplankton as the main source of food but adapted by changing the natural feeding and tend to be ineffective in utilizing the available food resources in the waters. During the study, both the types and amount of periphyton attached to the nets decreased. Higher commercial feeding level results in a higher density of periphyton in the floating nets.

Keywords: Female single sex nilem fish, food and feeding habits, grazing level, sustainable aquaculture

INTRODUCTION

Cirata reservoir (West Java, Indonesia) is a site for fish farming activities; one of which is the growing fish farming system of floating nets (Indonesian: *keramba jaring apung* or KJA). The number of floating net units in Cirata Reservoir has increased expeditiously, even reaching three times the number regulated by the government. The extensive and intensive activities in floating net system have carried great consequences in feeding. Generally, in lakes or reservoirs, feeding is supported with ad libitum system, i.e., the feeding is available at any time. Some researchers have indicated that about 20%-50% of unconsumed or wasted feed from the fish in the bottom of the water could be released into the body of the lake as pollutants. The food remains and solid discharge from the fish are decomposed to form organic and inorganic compounds; some of which are nitrogen compounds (NH_3, NO_2, NO_3) and phosphorus (PO_4) (Juaningsih 1997). In an anaerobic condition, decomposition may function, but this process also produces a variety of toxic gases that can pollute the water in the lake or reservoir.

Several approaches are suggested to address the deteriorating conditions and at the same time to initiate environment-oriented floating net improvements. First and foremost, it is important to note that the application of feeding should be in accordance with the needs of the fish. Secondly, it is also recommended to the increase utilization of feed to reduce the possible feed wasting in the waters by applying layered nets system in the trophic-level-based aquaculture. This can be achieved by farming fish with different feeding characteristics in each layer, such as combination of key commodities (carps and tilapias) respectively in the first and second layers of netting, while the herbivorous ones are kept in the third layer. One of the herbivorous species that can be used as a commodity is the nilem fish (*Osteochilus hasseltii* Valenciennes, 1842; syn. *Osteochilus vittatus* Valenciennes, 1842).

This research aimed to find out optimum commercial feed rate to make operational cost economic. Other than that, finding the optimum rate can reduce organic material waste entering the reservoir.

MATERIALS AND METHODS

Study area

Research was conducted from July to October 2014 in floating nets system of Cirata Reservoir, West Java, for the field experiment component of fish stocking. The Laboratory of Aquatic Resources Management was used for water quality analysis, as well as the Laboratory of

Aquaculture was used for food production and analysis. All laboratories and fish stocking belong to the Faculty of Fisheries and Marine Sciences, Universitas Padjajdaran, Sumedang, Indonesia.

Fish materials

The tools used in this study were: a 7 x 7 m^2 floating cages, 20 pieces of 1m x 1m x 1m nets, digital scales, ruler, plastic cup, and pH meter. Additionally, a Dissolved Oxygen (DO) meter, thermometers, the field equipment such as a dipper, bucket and others, camera, microscope, object glass and cover glass, hand counter, and dissecting kit were all used.

Materials used in this study were juvenile *O. vittatus* female fish, 3-4 cm in size and between 0.2-0.4 g of weight. The number of fish used for the study was 1,500 fish juveniles and 500 juveniles for each treatment. *O. vittatus* juveniles were obtained from the experiment ponds of Ciparanje, Faculty of Fisheries and Marine Science, Universitas Padjajdaran. The artificial fish feed used in the study was Shinta brands with protein content of 28%.

Meanwhile, in control treatment, the fish were not given any commercial feed and they utilize natural feed in Cirata Reservoir water, namely plankton and periphyton.

Procedures

Experimental design

The experiment was designed as a completely randomized design (CRD) consisting of 5 treatments and 3 replications. The treatments are as follows: (i) Treatment A = natural feed, (ii) Treatment B = 1% feeding of body weight per day, (iii) Treatment C = 2% feeding of body weight per day, (iv) Treatment D = 3% feeding of body weight per day, (v) Treatment E = 4% feeding of body weight per day.

Linear model used in this design is as follows (Gasperz 1991).

$$Xij = \mu + \tau i + \varepsilon ij$$

Where:

Xij : Yield of the experiment unit for the treatment of-i and the replicates of-j

μ : General mean value

τ : Effect of treatment of all i

εij : Effect of random factors from treatment of –i and replicates of- j (General error)

Data collection and observation variables

Survival rate. The survival rate was calculated by the equation:

$$SR = \frac{N_t}{N_o} \times 100\%$$

Where:

SR : survival rate (%)

N_0 : number of fish juveniles at the beginning of culture

N_t : number of fish juveniles at the end of culture

Daily growth rate. Daily growth rate is calculated using the equation:

$$G = \frac{\ln Wt - \ln Wo}{t} \times 100\%$$

Where:

G : daily growth rate (%)

Wt : average of individual weights at the end of the study (g)

Wo: average of weight of individuals before treatment (g)

T : Length of maintenance time (days)

Feed efficiency

$$EP\ (\%) = \frac{(Wt + D) - Wo}{JKP} \times 100\%$$

Where:

EP : Feed efficiency (%)

Wt : Biomass of fish at the end of maintenance/ culture (g)

Wo: Biomass of fish before treatment (g)

D : The weight of the fish that died during the study (g)

JKP: Amount of feed consumed during the study (g)

Data analysis

Data were analyzed using the analysis of variance (ANOVA). If the treatments resulted in a significant effect, the mean values among treatments were then analyzed using the Duncan's Multiple Range Test (DMRT) with a confidence level of 95% to determine the differences between treatments. The water quality was analyzed descriptively as additional information.

RESULTS AND DISCUSSION

Survival rate

Survival rate value is derived from the comparison between the number of organisms living at the end of maintenance and that of organisms living at the beginning of the stocking in percent where greater percentage indicates more organisms living during the maintenance period in a cultivation container (Effendie 1997). The results showed that for 42 days of treatment, female single sex *O. vittatus* have a high survival rate at above 95%. The survival rate of the control treatment (non-artificial feeding) and of artificial feeding at various levels ranged from 96% to 99.33% (Figure 1).

The female single sex *O. vittatus* reached the highest average of survival rate in treatment of 4% feeding of body weight per day about 99.33%, while the lowest was reached in the treatment of non-artificial feeding about 96%. Based on the analysis of variance, it can be concluded that the non-artificial feeding treatment did not give significant effect on the survival rate.

Compared with others, the result of this research is better than Rejeki (2013) culturing Nile tilapia 'larasati' in floating cage with the highest survival rate of 79.6%. According to Aquarista et al. (2012), survival rate can be used to measure tolerance and its ability to live in certain environments. By obtaining survival rates of 96-99.3%, rearing *O. vittatus* in floating cage in Cirata Reservoir is more suitable.

Daily growth rate

Growth is a change in the size of fish due to the increase in the length and weight in each period (Effendie 1997). Observation of the fish growth for 42 days of the treatment resulted in varied individual weight gain as a response to treatments (Figure 2). The daily growth rate of *O. vittatus* range from 4.13% to 5.17%, with the lowest value is in the non-artificial feeding treatment (4.13%), which continues to increase until the 3% feeding (5.17%). On the latest treatment, the growth rate tends to decline only to 4.99%.

The effects of the treatments on the growth rate can be determined from the analysis of variance. Results indicate significant effect of the artificial feeding treatment on the growth rate of the fish. The further mean value test using Duncan's multiple Range resulted in the fact that the growth rate of the non-artificial feeding treatment was different from those with artificial feeding at various levels.

The result is also like Andriani et al. (2016) and proves that the use of only natural feed is not sufficient to meet the fish requirement, because it does not contain complete nutrition. The use of two or more protein sources in the feed is better than one source only (Madinawati et al. 2011).

The best growth rate from this research is higher than that found by Yudhistira (2013) where fermented herb given to *O. vittatus* gives the higher rate of 1.46%. The higher rate of *O. vittatus* is associated with a warm water temperature of Cirata reservoir. This is like the statement of Wicaksono (2013) that external factors such as ambient environment, quantity and quality of food in meeting fish nutrition requirement, energy content in the food, and availability of materials in the food influence fish growth rate.

Feed efficiency

Feed efficiency is the utilization of feed to increase fish growth (Nugraha 2011). Based on the research results, the highest feed efficiency occurs in the 3% artificial feeding treatment of 55.30% and the lowest feed efficiency is in the 1% artificial feeding treatment of 40.04% (Figure 3).

Analysis of variance of feed efficiency showed that the feeding material and levels did not give significant effect. Non-artificial feeding differs from treatments with artificial feeding. *O. vittatus*es responded remarkably to the feeding treatment during the research shown by no trace/remains of feed at each feeding period. This indicates that the fish have a wide range of adaptability to feeding variations. Furthermore, utilization of feed by fish is reflected by the relatively high growth and feeding efficiency value (55.30%.).

The bigger food efficiency value the more food portion that can be taken and accumulated as biomass or the increment of its flesh. A linear correlation was found between amylase activity and digestibility in response to dietary. Furthermore, rates of food efficiency and growth are correlated linearly with the apparent digestibility of dry materials (Chen 2013).

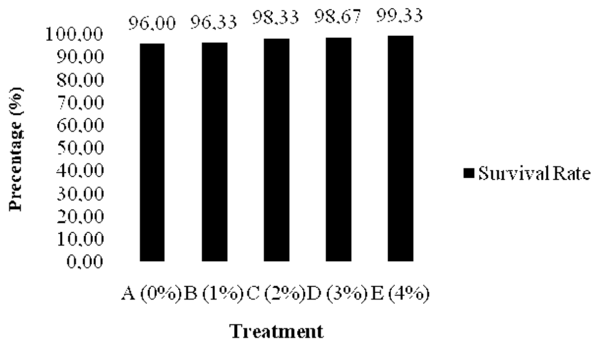

Figure 1. Survival rate of female single-sex *Osteochilus vittatus* during the experiment.

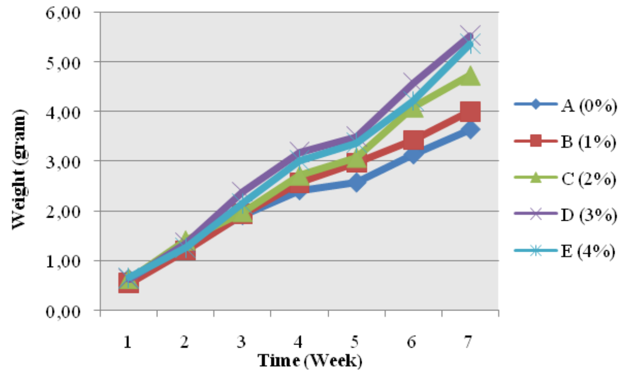

Figure 2. Weight gain of *Osteochilus vittatus* during the research

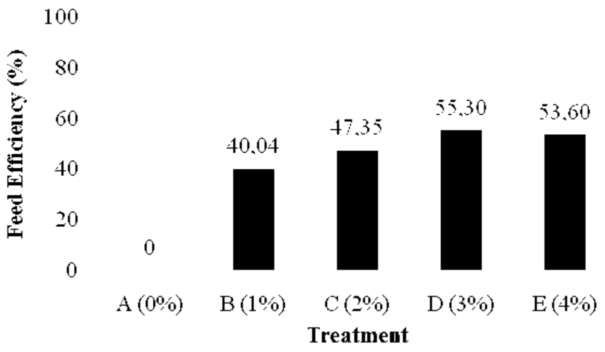

Figure 3. Feed efficiency of female single-sex *Osteochilus vittatus* during the research

Treatment with 4% of commercial feeding showed a decrease in feed efficiency compared to that of in 3% feeding. Feeding 4% affects insignificantly to the growth due to the nature of herbivorous behavior of *O. vittatus* on the lacking the enzymes and digestive fluids to absorb the artificial food (German, 2004). The research of German (2004) shows that there is a difference between enzyme activity in carnivorous and herbivorous fish. Fish will modulate the activity of its digestive enzyme as a response to the change of the food.

This illustrates that if the fish in floating nets of Cirata are cultivated with commercial/artificial feeding, it should be no less than 3%. The feed efficiency value in this study is 55.30%, higher compared to the research results from Yudistira (2013), in which the feed efficiency of fermented lettuce is only 24.85%.

Feeding habits

The composition of plankton as natural feed in the waters of Cirata consists of three classes and 23 genera of phytoplankton and three classes and 4 genera of zooplankton. Phytoplankton of Bacillariophyceae class consists of 11 genera with an average abundance of 605 individuals per liter, Chlorophyceae of 13 genera with an average abundance of 389 individuals per liter, and Cianophyceae of 4 genera with an average abundance of 152 individuals per liter, while the zooplankton consists of 2 genera of Crustaceans, 1 gene for each Euglenoidea and Rhizopoda with an average abundance of 118 individuals per liter (Figure 4).

The individual abundance of phytoplankton was larger than zooplankton population. Such condition is considered normal in an ecosystem as primary producers remain at the bottom of food pyramid and occupy the largest space in the system (Taofiqurohman et al. 2007).

Analysis of the *O. vittatus* digestive organs of female single sex found three types of food including phytoplankton, zooplankton, and artificial feed. Fish graze on 23 genera of phytoplankton comprising three classes of Bacillariophyceae, Chlorophyceae and Cyanophyceae, and zooplankton from Crustaceans class of *Cyclops*, and Rhizopoda class of *Arcella*. Nikolsky (1963) classifies the feeding habits based on three categories i.e., the natural food when the preponderant index is more than 25%, supplementary feed when the preponderant index is between 2% to 25%, and complete feed when the preponderant index is less than 5%. The research suggests that *O. vittatus* cultured in floating nets of Cirata Reservoir possess 0% to 57% of preponderant index indicating the full utilization of all types of feed in the water.

Trophic level

Trophic level is the order in the use of foods or materials and energy as defined by the food chain. Calculation on the trophic level is based on the correlation between the organism's trophic level and feeding habits of the fish to determine the position of the fish in an ecosystem (Tjahyo 2000). *O. vittatus* in this research occupied the trophic level of 1.03 to 1.45 that indicating the herbivorous character of the species (Figure 5). The lowest trophic level was found in the group that was given by non-artificial feed in the first week, and the highest number was given by the group fed up with artificial food of 4% in the third week. The varied numbers do not change the trophic level status as fish still graze on the phytoplankton in the water as food resource as found in the digestive tract.

The abundance of phytoplankton and periphyton species

The types and abundance levels of phytoplankton and periphyton in the floating nets of Cirata varied in both the number and kind, during observations. The largest average number of phytoplankton comprised the groups of *Oscillatoria* (1078.00 species), *Navicula* (585.47 species), and *Nitzschia* (315.53 species), while the zooplankton showed the biggest number of *Arcella* with the average number of individuals of 387.27 species (Figure 6).

The periphyton found in the floating nets consists of phytoplankton groups of Bacillariophyceae (8 species), Chlorophyceae (5 species), and Cyanophiceae (3 species). Furthermore, the periphyton consists of Euglenoidea (1 species), Rhizopoda (1 species) and Rotatoria (2 species). The nine species of phytoplankton were from Bacillariophyceae (6 species), Chlorophyceae (2 species), and Cyanophiceae (1 species) decline at the sixth week; seven of them are *Symbella, Spyrogyra, Crucigenia, Spirulina, Merismudesmus,* and *Pinularia* decreased to 100% or were fully consumed. Similarly, the number of species of zooplankton has decreased from the first week and it is identified that from four species at the first week have declined remaining two species at the sixth week. The species *Diurella* and *Branchionus* were fully consumed at the sixth week (Figure 7).

Osteochilus vittatus have high preference towards periphyton, as seen from the declining types, from four species to 2 species with a significant amount of consumption from 55.59% to 100%. The preference is derived from, not only from the size that fits into the larva's mouth opening, but also from highly active character of zooplankton that stimulates the fish juveniles to consume (Hardjamulya 1979).

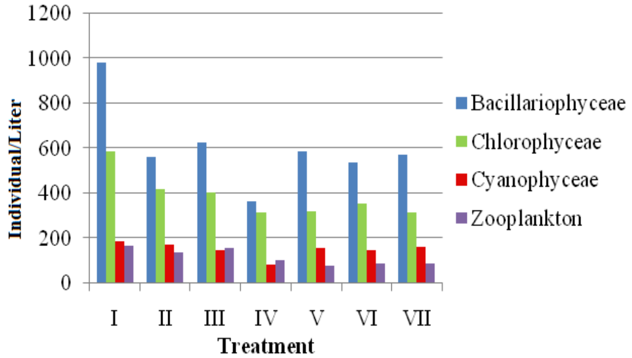

Figure 4. Abundance of plankton as food resources in water of Cirata reservoir

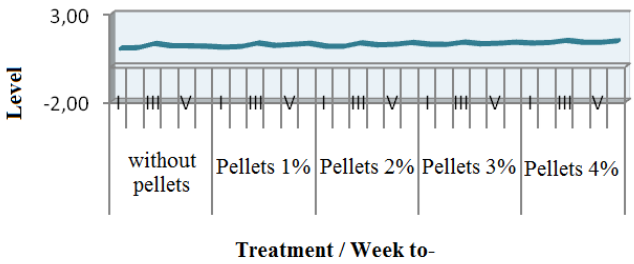

Figure 5. Trophic level of *Osteochilus vittatus* for 6 weeks of search

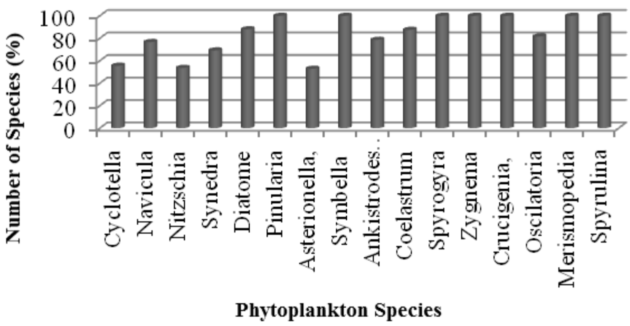

Figure 6. Percentage of periphyton (from phytoplankton) consumed by *Osteochilus vittatus* juveniles

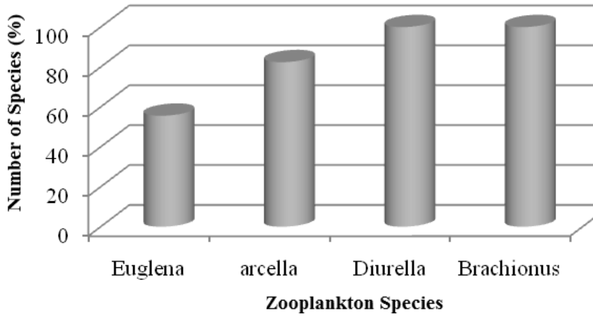

Figure 7. Percentage of periphyton (from zooplankton) consumed by fish juveniles

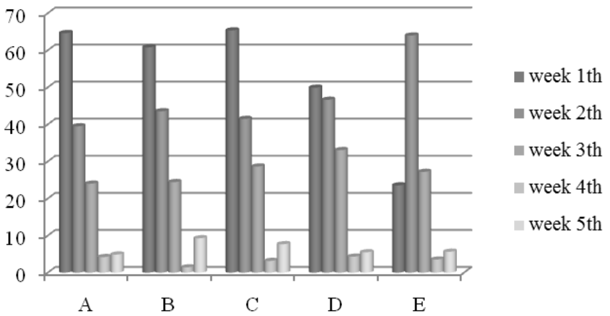

Figure 8. Grazing level of *Osteochilus vittatus* juveniles due to the treatment

The grazing levels

A 5-gram *O. vittatus* requires 6.373 g of periphyton attached to 19 m^2 net substrate to grow to 100 g because periphyton contains 0.46% of protein and 97.06% of water (Harris (2006). This indicates that the *O. vittatus* is suitable species as an alternative to overcome the problem of blooming phytoplankton in the waters.

Treatments A, B, C, and D showed similar pattern of the grazing level trend from the first week of sixth week. The Grazing level of *O. vittatus* was decreased during the time for all treatments. The condition could be due to the declining availability of periphyton in the nets. In treatment E, where the fish were fed with 4% of artificial feed, the grazing level declined from the third week, and it is assumed that on first and second week, the *O. vittatus* are still not attracted to consume the artificial food. In natural water, living food is in motion so that the fish are attracted to go after it. Attractive food will stimulate fish appetite and hence they can survive (Widodo 2010).

On those weeks, the grazing level is still high i.e. 134 ind.cm^{-2} and 111 ind.cm^{-2} respectively, while the grazing level slowly declined on the third week to the fifth week, from 47 ind.cm^{-2}, 20 ind.$cm^{2,}$ 16 ind.cm^{-2}. Deterioration in grazing occurs because of the option between artificial food and periphyton as food resources.

In conclusion, analysis of the survival rate and growth proves that there is no difference between female single sex of *O. vittatus* in floating nets Cirata Reservoir fed with non- and artificial food. The highest feeding efficiency is obtained by artificial feeding of 3% treatment amounting up to 55.30%. Female single sex *O. vittatus* are herbivores with trophic level between 1.03 to 1.45. *O. vittatus* is generalist and grazes on plankton as a food source. The *O. vittatus* fed with artificial food of 4% from biomass still consume phytoplankton as a main source of food, but the experience changes in the feeding habits and tends to be ineffective in utilizing the available food resources in the waters. During the study, the types and amount of periphyton attached to the nets tend to decrease. Higher level of artificial feeding causes higher density of periphyton. The grazing level of each treatment is relatively similar, but higher commercial feeding level tends to decrease the grazing level on the periphyton.

It is suggested that female single-sex *O. vittatus* could be used as a controlling organism for the growth of phytoplankton and as a bio-cleaning agent of periphyton in Cirata Reservoir.

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REFERENCES

Andriani Y, Rostika R, Haetami K. 2016. Fish Nutrition. Textbooks. Unpad Press, Bandung [Indonesian]

Aquarista, Iskandar F, Subhan U. 2012. Giving Probiotics with Zeolite Carrier At Dumbo Catfish Enlargement (*Clarias gariepinus*). Fish Mar 3 (4): 133-140.

Effendie MI. 1979. Fisheries Biology. Yayasan Pustaka Nusantara, Bandung. [Indonesian]

German DP, Horn MH, Gawlicka A. 2004. Digestive enzyme activities in herbivorous and carnivorous prickleback fishes (Teleostei: Stichaeidae): ontogenic, dietary, and phylogenetic effect. Physiol Biochem Zool 77 (5): 789-804.

Hardjamulia A. 1979. Aquaculture: Cultivation of Mas Fish (*Cyprinus carpio* L.), Tawes Fish (*Puntius javanicus*), Nilem Fish (*Osteochilus hasseltii*). School of Fisheries Science, IPB, Bogor & Agricultural Education, Training and Extension Agency. Dept. Agriculture GoI, Jakarta. [Indonesian]

Harris E. 2006. Aquaculture Based "Trophic Level": Revitalization for Food Security, Export Competitiveness, And Environmental Sustainability. Scientific Oration of Professor of Permanent Aquaculture Science. Faculty of Fisheries and Marine Sciences, IPB, Bogor [Indonesian]

Madinawati N, Serdiati, Joel. 2011. Giving different feeding to growth and survival of dumbo catfish seed (*Clarias gariepinus*). Media Litbang Sulteng. 4 (2): 83-87

Nikolsky GV. 1963. The Ecology of Fishes. Academic Press, New York.

Nugraha RH. 2011. Identification and Study of Fish Food Habit in Cimanuk River Sumedang District, West Java. [Thesis]. Faculty of Fisheries and Marine Sciences, Universitas Padjadjaran, Sumedang. [Indonesian]

Rejeki S, Hastuti S, Elfitasari T. 2013. Fish Cultivation Test of Nila Larasati in Karamba Floating Net with Solid Tebar Different. Saintek Fisheries 9 (1): 29-39.

Taofiqurochman AS. 2007. Study of Food Habits of Nilem (*Osteochilus hasselti*) in Tarogong, Garut District. [Thesis]. Faculty of Fisheries and Marine Sciences, Universitas Padjadjaran, Sumedang. [Indonesian]

Tjahjo DWH. 2000. Biolimnology and Potential Fish in the Waters of Darma Reservoir, West Java. Indonesian Fish Res 3 (2): 10-15.

Widodo W, Handajani H. 2010. Fish Nutrition. UMM Press, Malang. [Indonesian]

Yudhistita S. 2013. Effect of Leaf Apu (*Pistia stratiotes*) Fermentation in feed to daily growth and conversion of nilem fish seed feed. Faculty of Fisheries and Marine Science. Universitas Padjadjaran, Sumedang. [Indonesian]