Evaluation of simple feeding technology on growth and feed efficiency of tilapia in cage aquaculture at South Kalimantan, Indonesia

by Ika Sumantri

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Abstract

The objective of this study was to evaluate the effectiveness and efficiency of the automatic funnel feeding in cage aquaculture system (*karamba*). The examined feeding systems were an automatic funnel and a conventional method. The experiment was run for 8 weeks. The weight of the fish samples was measured every 2 weeks. The observed variables were individual weight gain (WG), specific growth rate (SGR), mortality (M), and feed consumption (FC). The unpaired t-test was applied to compare the feeding methods. Results showed that there were no significant differences in WG, SGR, M and FC of the two feeding methods. Feeding with the automatic funnel provided more benefits because it can save labour costs and reduce offered feed. Moreover, automatic feeding reduced the amount of feed entering the aquatic ecosystem thus it reduced the pollution load due to cage aquaculture. It is suggested that automatic funnel feeding technology resulted in similar fish productivity while it is more environmentally friendly in the cage aquaculture production system.

Keywords: *cage aquaculture, automatic funnel, conventional feeding, fish growth rate, fish weight*

Introduction

Fish is the main source of animal protein in the human diet in many countries in Southeast Asia, especially archipelagic countries such as Indonesia. Even fish will be the most affordable source of animal protein for millions of people in developed and developing countries. Besides being easy to get, fish also contains healthy levels of nutrients. and a good source of thiamine, riboflavin, vitamins A and D, phosphorus, calcium and iron (FAO 2020). The demand for fish as a source of animal protein continues to increase along with the increase in population, while the availability of fish tends to decrease. In Indonesia, the demand for fish is fulfilled by the supply from fish capture and aquaculture.

Aquaculture in the river by using cages (*karamba* system) has been practised by the community in many rivers in South Kalimantan, Indonesia. This fish farming has a large economic contribution to people in the wetland area of South Kalimantan. However, there are many difficulties in *karamba* system that affect aquaculture profits, such as high fish mortality which is ranging from 10% - 50% (Rahman et al 2017). High fish mortality in *karamba* system is mainly caused by the accumulation of organic matter from uneaten feed and fish excrete around the cages (Herliwati and Rahman 2022; Iqbal et al 2018).).

The uneaten feed and excrete from fish farming enter the aquatic environment which will reduce water quality, inhibit fish growth, and cause fish mortality. The accumulation of organic substances from the uneaten feed in the river will stimulate microbial activity which can cause deoxygenation of the substrate and water due to a reduction in oxygen concentration. Reducing dissolved oxygen levels to anaerobic conditions will stimulate the formation of ammonia, hydrogen sulfide, and nitrite which are toxic to the fish (Boyd et al 1998). Deoxygenation conditions and increasing levels of ammonia, hydrogen sulfide, and nitrite are the main causes of mass mortality in cage aquaculture (Herliwati and Rahman 2022; Baverage 2004). The high mortality of fish in fish farming indicates the carrying capacity of the water environment and pollution levels has exceeded the fish tolerance.

The price of commercial fish feed is also an important issue in aquaculture. The increasing price of fish feed reduces the profits of fish farmers. Feed is a key factor in the success and sustainability of the cage aquaculture business (Okoye and Sule 2001). Feed cost is considered the largest part of production costs that reach more than 65% of production cost (Pallaya-Baleta et al 2022; Ashley-Dejo et al 2017; Ahmed et al 2007).

The use of cage (*karamba* system) in aquaculture has spread to all regions in South Kalimantan Province. Besides being a source of animal protein and having economic benefits, this production system also has social benefits namely creating jobs.

In order to improve the benefits and sustainability of the cage aquaculture system in the river, a better fish feeding technology is needed that can improve feed efficiency, reduce water pollution, and reduce the fish mortality rate. Akinrotimi et al (2007) and Jamu and Ayinla (2003) stated that feeding management determines the viability of fish farming.

An automatic funnel innovation has been developed by cage fish farmers in several rivers in South Kalimantan to improve feed efficiency. However, it is necessary to evaluate the effectiveness of this feeding technology on fish growth and mortality. Thus, this tool can be promoted for more beneficial and sustainable cage aquaculture system.

Materials and methods

Study Area

This research was carried out in Hanyar river, a sub order of Tabalong River, South Kalimantan province, Indonesia.

Research material and Experimental set-up

Three units of fish cages (*karamba)* were used in the experiment (L=2m, W=1.5m and D=1m) and each unit was divided into two parts so that it becomes 6 cage units (L=1m, W=1.5m and D=1m). Two feeding systems were evaluated, namely feeding using an auto funnel and conventional feeding. Fifty *Oreochromis niloticus* (Tilapia*)*, which were procured from a fish hatchery in Kambitin Tabalong regency, were stocked per cage unit (average initial weight of 1.96±0.397g). The cages are placed sequentially in the direction of the water flow (Photo 1).

Photo 1. Cage aquaculture unit used in the experiment

The automatic funnel is designed by placing the funnel frame at the top of the cage. A lever is inserted in the funnel that connects the inside of the funnel and the cage. If the end base of the lever, which is submerged in water, was touched by the fish, the valve on the funnel will be open and the feed will fall into the cage. Thus the feed will only fall from the funnel into the cage if the fish touch the lever on the inside of the cage. Every two days the feed in the funnel was controlled to check if the feed runs out.

The conventional feeding method is done by spreading the feed directly into the cage. Feeding times were twice per day namely at 08.00 AM and 05.00 – 06.00 PM. Feed was offered as much as 5% of body weight per day. The type of feed used in the experiment was the same feed ty for both feeding techniques, namely commercial feed in the form of floating pellets with a protein content of 30 - 33%, fat of 4%, the fibre of 5%, ash of 13%, and water content of 12%. The weight of feed given directly to the cage (conventional method) and entering the cage through an automatic funnel is calculated as the weight of the feed given to the cage fishery.

Evaluation of growth parameters

The experiment was run for 8 weeks and every 2 weeks the fish samples were weighed to collect the data. The observed variables were individual weight gain rate (WG), specific growth weight (SGR), mortality rate (MR), and feed consumption (FC).

$$WG = \frac{(Final\ body\ weight - Initial\ body\ weight)}{Initial\ body\ weight} \times 100\%$$

$$SGR = \frac{(Final\ body\ weight - Initial\ body\ weight)}{Number\ of\ days} \times 100\%$$

$$MR = \frac{Number\ of\ dead\ fish}{Initial\ number\ of\ fish} \times 100\%$$

FC = the amount of offered feed (g)

Data Analysis

The variables of two feeding methods were compared using unpaired t-test (t-test: Two Samples with Equal Variance Assumption) at ($p < 0.05$). All computation was performed using a statistical package in the excel software.

Results

Weight gain rate (WG)

The individual weight gain and individual weight gain rate of tilapia during the 8 weeks of the experiment are shown in the Table 1 and Table 2 below.

Table 1. Individual weight gain (g) of tilapia during experiment

Cage Unit	Weeks of observation				
	W0	**W2**	**W4**	**W6**	**W8**
F1	2.14±0.25	8.52±2.10	12.20±1.55	39.10±3.07	69.50±3.81
C1	2.14±0.40	9.95±3.21	13.00±1.49	42.10±2.77	71.75±4.06
F2	1.97±0.29	4.85±0.88	7.05±0.76	13.50±1.08	38.60±2.01
C2	2.11±0.40	5.33±0.79	7.65±1.00	13.80±1.32	40.80±3.19
F3	1.57±0.44	4.82±0.76	7.95±0.86	15.90±1.37	38.90±1.79
C3	1.84±0.31	5.62±1.54	8.00±0.97	16.70±1.57	40.10±3.21

W0 = initial week; W2 = 2nd week; W4 = 4th week ; W6 = 6th weeks ; W8= 8th week$F_{1,2,3}$ = cage with automatic funnel; $C_{1,2,3}$ = cage with conventional method

The weight gain rate of individuals between caged units is highly variable. The highest individual weight gain rate was found in cage unit 1 and the lowest individual weight gain rate ware found in cage unit 2. Furthermore, the relative growth data was transformed for statistical test purposes. The results of the logarithmic transformation of individual relative growth data during the rearing period can be seen in Table 3.

Table 2. Individual weight gain rate (%) during experiment

Cage Unit	Treatments	
	Automatic funnel	**Conventional method**
1	3.147,66	3.252,80
2	1.859,39	1.833,65
3	2.377,71	2.044,39

Table 3. Individual tilapia weight gain rate (%)

Cage Unit	Treatment	
	Automatic funnel	**Conventional method**
1	3.50	3.51
2	3.27	3.26
3	3.38	3.31

Specific growth rate (SGR)

The large SGR variation between sampling periods (2.19% d^{-1} - 2.19% d^{-1}) could be seen in Table 4. The lowest daily growth of individuals was found in the 4th week of the sampling period and the highest occurred in the 6th week of the sampling period.

Table 4. Specific growth rate (% d^{-1}) of tilapia during 8 weeks

No. cage unit	Sampling period (weeks)	Automatic funnel	Conventional method
1	2	21.30	26.07
	4	3.09	2.19
	6	15.75	15.99
	8	5.55	5.03
2	2	10.44	10.90
	4	3.17	3.11
	6	6.63	5.74
	8	13.28	13.98
3	2	14.79	14.32
	4	3.52	2.65
	6	7.14	7.77
	8	10.33	10.01

Mortality rate (MR)

Calculation of dead fish was carried out every 2 weeks for 8 weeks of the experiment, along with sampling and weighing of fish. The number of live fish every 2 weeks and during the 8 weeks can be seen in Table 5, and fish mortality in Table 6.

Table 5. Number of live fish on sampling period (2 weeks) during the experiment

Cage unit	Treatment	Weeks 0	2	4	6	8	Number of dead fish
1	Auto. Funnel	50	49	47	47	45	5
	Conventional	50	50	50	49	47	3
2	Auto. Funnel	50	47	45	44	44	6
	Conventional	50	50	47	46	43	7
3	Auto. Funnel	50	46	45	44	42	8
	Conventional	50	49	46	45	43	7

Table 6. Mortality (%) of fish during the experiment

Cage unit	Treatment	Weeks 2	4	6	8	Total Mortality
1	Auto Funnel	2,00	4,08	0,00	4,26	10,00
	Conventional	0,00	0,00	2,00	4,08	6,00
2	Auto Funnel	6,00	4,26	2,22	0,00	12,00
	Conventional	0,00	6,00	2,13	6,52	14,00
3	Auto Funnel	8,00	2,17	2,22	4,55	16,00
	Conventional	2,00	6,12	2,17	4,44	14,00

The mortality of the 2-week sampling period for the automatic funnel feeding ranged from 0.00 – 4.55% (3.31% ± 2.345) and the conventional feeding ranged from 0 – 6.52% (2.95% ± 2.427). The total mortality during the 8-week of experiment ranged from 10.00 – 16.00% (12.67% ± 3.055) and 6 – 14% (11.33% ± 4.619), respectively.

Feed consumption

The daily amount of feed consumed by tilapia is calculated based on the amount of feed offered through to the fish, either through the funnel or conventional feeding. The daily offered feed (kg $cage^{-1}$) is presented in the Table 7.

Table 7. Daily offered feed (kg $cage^{-1}$)

No. cage Unit	Automatic funnel	Conventional feeding
1	0.105	0.158
2	0.325	0.175
3	0.625	1.000
average	0.352	0.444

The daily average amount of offered feed (kg $cage^{-1}$) by conventional method was more than automatic funnel. Thus, the use of feed in the automatic funnel is more efficient than the conventional method.

Statistical Analysis

The unpaired t-test is presented in the Table 8 below.

Table 8. Result of t-test

Variable	Observation		Mean		Variance		t-Test (p<0.05)	
	funnel	convent	funnel	convent	funnel	convent	t_{stat}	$t_{critical}$
WGR	3	3	3.381	3.362	0.013	0.017	0.1895	2.7764
SGR	12	12	9.582	9.813	33.483	49.025	0.0879	2.0739
MRs	12	12	3.313	2.956	5.493	5.893	0.3665	2.0739
MRt	3	3	12.667	11.333	9.333	21.333	0.4170	2.7764
FC	3	3	0.3516	0.4443	0.068	0.232	0.2931	2.7764

WGR = Weight gain rate; SGR = Specific growth rate; MRs = Mortality rate on sampling period; MRt = Mortality rate during experiment

Statistical analysis showed that theres is no significance different of two feeding systems ($p<0.05$) on the weight gain rate of individual ($t_{stat} = 0.1895 < t_{critical} = 2.7764$); the specific growth rate (t_{stat} value $= 0.0879 < t_{critical}$ 5% $= 2.0739$); mortality rate ($t_{stat} = 0.4170 < t_{critical} = 2.776$); and the amount of offered feed ($t_{stat} = 0.2931 < t_{critical} = 2.776$) to individuals tilapia during the 8-week experiment period.

Discussion

High fish mortality is the main issue in the cage aquaculture production system. Some factors might contribute on the fish mortality, such as dissolved oxygen depletion, increased levels of ammonia and nitrite around the cage (Daunda et al 2019). This poor water quality was caused by the accumulation of uneaten feed and fish excrete around the cage which undergoes biodegradation under anaerobic conditions. The high fish mortality in cage aquaculture or floating net was repeatedly occurred in Indonesia. It wa reported that 1,042 tons fishes died in the floating net at Saguling reservoir in 1993, 1,039 tons in the Cirata reservoir in 1994, 1,560 tons in the Juanda-Jatiluhur reservoir in 1996 as a result of water fertilization sources from aquaculture (Krismono 2004), and uncontrolled increase in the number of cage aquaculture (Machbub 2010). This phenomenon tends to reoccurred annually in reservoirs and lakes on the islands of Java and Sumatra. The same case has been experienced by cage aquaculture farmers in the Riam Kanan river at the end of 2012 which caused 2,340 tons were died (Herliwati and Rahman 2022) and repeated in October 2019. At the end of 2019, as many as 80 tons of fish cage aquaculture died in Martapura river. The high density of cages is one of the causes of the decrease in the carrying capacity of the river (Rahman et al 2017).

Therefore, feed is a key factor in ensuring the sustainability of the cage aquaculture business. Inadequate amount of feed given and the low nutrients content of the feed will inhibit the growth of the fish at a aquaculture (Abd El-Naby et al 2020). On the other hand, overfeeding will have an impact on reducing water quality which can lead to an increase in fish mortality and even large-scale mortality of cultured fish (Hasim et al 2017; Chitmanat et al 2016). Thus, controlled feeding technology is needed to avoid overfeeding.

The development of feeding technology can be a solution a reduce uneaten feed wasted into the aquatic environment (Yue and Shen 2022). Various feeding technologies from digital technology to nanotechnology have been developed (Abd El-Naby et al 2019; Fajardo et al 2022.). However, this technology is still not effective because it requires the support of electronic devices, technology control, additional business capital and there are still many locations for cage aquaculture business activities that have not been reached by the internet network. While cage aquaculture is mostly adopted by smallholder fish farmer. Thus the development of a simple technology that is in accordance with local conditions is the most appropriate choice.

Conclusions

- The automatic funnel feeding and conventional feeding method had similar effect ($p<0.05$) on the weight gain rate of individual, specific growth rate, mortality rate and the daily amount of offered feed (kg cage $^{-1}$) variables.
- Feeding with an automatic funnel provides an advantage because it saves labour cost, avoid overfeeding, and reduce water pollution from cage aquaculture.
- The automatic funnel technology is feasible to be applied to the cage aquaculture production system in the river.

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