Mutualism Symbiosis of Silkworm and Catfish Aquacultureto Provide Fish-based Protein for Local Community in Salak Malang Hamlet, Banjarharjo Village, Kalibawang District, Kulon Progo Regency

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ABSTRACT

The application of appropriate technology on the concatenate of silkworm (*Tubifex tubifex*) and catfish (*Clarias sp.*) aquaculture was carried out in Salak Malang and Salam Hamlets, Banjarharjo Village, Kalibawang District, Kulon Progo Regency, Special Region of Yogyakarta, Indonesia. The main concept of this appropriate technology is to establish a mutualism symbiosis by creating water recirculation between silkworms and catfish ponds. The results show that an increase in the water flow frequency from catfish ponds to silkworm culture areas has the potential to provide higher silkworm production. The integration of silkworm and catfish aquaculture may also reduce catfish's Feed Conversion Ratio (FCR) to around 0.7-0.9. This alleviation in FCR value indicates the feed efficiency that reduces feed costs, making catfish farming more effective and efficient. By applying this appropriate technology, the number of silkworms required for catfish seed in Banjarharjo Village would still be fulfilled, and simultaneously the availability of fish-based protein from catfish available for the silkworm farmer and the local community.

Keywords: Aquaculture wastewater, Feed conversion, Fish-based protein, Integrated Aquaculture.

1 Introduction

Salak Malang Hamlet is located in the north-western part of the Special Region of Yogyakarta, specifically in Banjarharjo Village, Kalibawang District, Kulon Progo Regency. This hamlet has a total population of 367 people. The Banjarharjo Village has 22 hamlets, including Salak Malang and Salam, as the center of aquaculture activities.

During the COVID-19 pandemic, if we take a further look apart from its health factor and impacts, food availability is also essential for the community. The restriction of social activity's (also known as PPKM) implementation hinders the distribution of food supplies. Therefore, the activity of aquaculture in Salak Malang Hamlet was also impacted. Fortunately, as we entered the post-pandemic phase, the market circumstances regarding aquaculture slowly turned back to normal as the demand from consumers started to increase. However, some fish farmers still hesitate to re-establish their aquaculture production, and some even start reducing the number of operational ponds and stocking densities. This condition could lead to a fish stock shortage in the market.

As the main aquaculture commodity in Kalibawang District, catfish are accessible as incubators for consumption-sized catfish for marketing purposes. The cultivated catfish is used to fulfill the needs of the local Kalibawang district community within 6,685.5 kg/month. Catfish farming requires a lot of natural food sources, especially for seed production[1]. One of the best alternatives for natural food is silkworm (*Tubifex tubifex*) [2]. Silkworm cultivation is considered easy, costless, and can be harvested diurnally. Thus, as the catfish's demand on the market increases, the exigency of silkworms is likewise. There are ten silkworm farmers in Salak Malang Hamlet—with an estimated production of 50 liters per day and a total of 2500 m² silkworm pond.

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Silkworms (*Tubifex sp.*) contain 66.26% of protein [3]. According to the nutritional content, silkworms can be used as nourishment for various fish seeds. In Kulon Progo Regency, the production of catfish seeds in 2021 is around 29,700,000 individuals; this number requires around 21,000 liters of silkworms annually. These high demands provide an opportunity for silkworm farmers to increase silkworm availability and production. However, silkworms are required as extra feed due to a shortage of commercial fish pellets.

In this activity, we implement the appropriate technology to produce better outcomes. For example, silkworm cultivation requires water with high nitrogen (N) content[4]. In the natural system, the nitrogen contained in the water usually derives from animal waste, also excreted by catfish. The catfish cultivation's water contains a lot of nitrogen as a secondary product of protein digestion[5]. In addition, wastewater from catfish farming ponds can be pumped to silkworm cultivation sites so that silkworms can utilize the nitrogen content in the water.

The water from the silkworm pond can be recirculated back to the catfish pond to make the cultivation process more efficient. The silkworm pond's water flow allows some silkworm colonies to be carried by the water stream, which catfish can use as an additional food source. This condition may reduce the value of the catfish's Feed Conversion Ratio (FCR). By this, we hypothesize that this condition will lead to the mutualism symbiosis between the silkworm and catfish aquaculture. The silkworm culture receives the high nitrogen content water as the fertilizer to improve its production, whereas the catfish gets the additional food source from the silkworm colonies carried out by the water. This activity aims to provide the silkworms with catfish seed feed in Kalibawang District and fish-based protein from catfish cultivation for the silkworm farmers and the community.

2 Research Methodology

This appropriate technology implementation was implemented in Salak Malang and Salam Hamlet in Kalibawang District, Special Region of Yogyakarta, Indonesia. The design of this silkworm-catfish integrated pond is described in figure 1. The silkworm pond is created as the raceway pond design, followed by the sedimentation pond to reduce the water's turbidity and undertake the water before entering the catfish pond at the end of the system. The water from the catfish pond's outlet is pumped into the silkworm pond's inlet. Therefore, the water used is recirculated in this system.

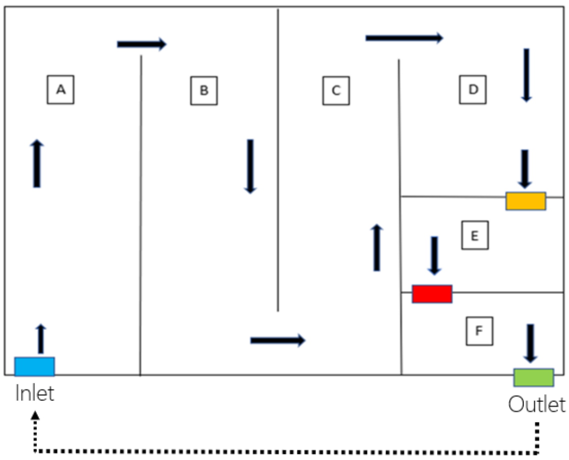

Figure 1: *Silkworm-catfish aquaculture integrated design. [A-D] silkworm pond, [E] sedimentation pond, [F] the catfish pond. Arrow shows the water flow in the system.*

This appropriate technology implementation consists of several steps: land or soil preparation, pond construction, seed stocking, and commodity harvesting (Figure 2.). Land or soil preparation is done by the soil's initial fertilization, including establishing the silkworm pond's water flow with a flow path width of around two meters. The next step is the construction of catfish ponds with a size of 2×4 m²—built at the end of the silkworm pond. The pump system connecting the catfish ponds with the silkworm ponds' inlet was also built to make the recirculation of water flow in the system more accessible.

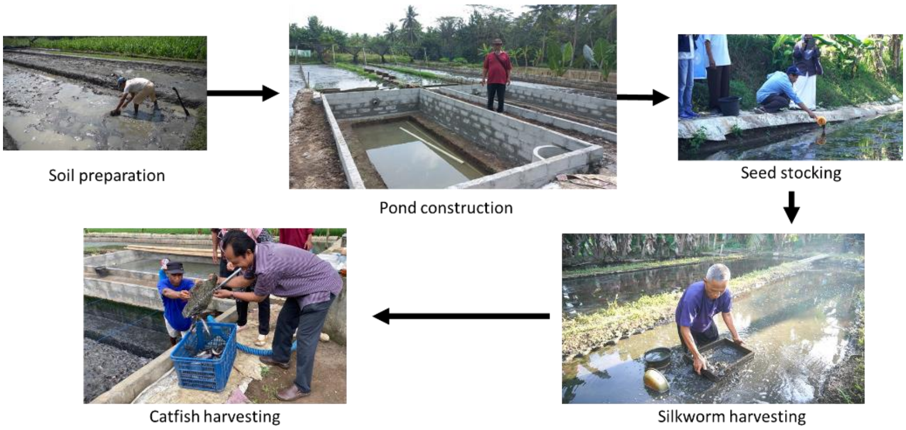

Figure 2: *Appropriate technology implementation steps*

After the pond construction, the next step is seed dispersal. The silkworm seeds were carried out for about 30 liters for each 600 m² silkworm pond area. As for catfish, around 1,000 individual seeds (6-8 cm in length) were added for every 8 m² catfish pond. Catfish are given commercial pellet feed (size 3 mm) twice a day diurnally, weighing around 3-5% of catfish biomass. Soil dispersal is done daily in the silkworm pond to distribute soil nutrients evenly.

Silkworm harvesting can be done daily, whereas catfish harvesting can be done after 3-4 months. During the cultivation process, commercial feed use and daily silkworm production were recorded to determine the effect of this integration on aquaculture efficiency. The parameter of catfish FCR was juxtaposed and analyzed descriptively to find the most efficient method compared to the conventional method.

3 Results and Discussion

From the three sets of silkworm-catfish integrated ponds, the total catfish production reaches 523 kgs, with only 465 kg of commercial fish feed used (Table 1). The catfish FCR in this case, ranges from 0.77 – 0.9, while the FCR value for catfish is commonly around 1.1-1.4 in the conventional method[6]. A lower FCR value indicates catfish utilization for the commercial pellet is more effective. This condition could happen because of silkworm cultivation's additional natural food source.

The frequency of water flow in the system could be the factor that influences the catfish FCR value. There is a tendency for continuous flows to lead to a lower catfish FCR value. This condition might be related to the availability of additional feed, which is always procurable at a continuous flow frequency. Meanwhile, at lower water flow frequencies, the existence of silkworms as additional feed is not always available for catfish. Therefore, it makes the FCR value more significant compared to systems with continuous water flow.

There is also a difference in silkworm cultivation productivity between farmers. In the continuous flow frequency method, silkworm production remains constant occasionally. On the other hand, the fewer flow frequency of water in the system might contribute to the fluctuation of silkworm production, as stated in Farmer 1. The highest silkworm productivity is shown in Farmer 3, which can produce silkworms up to 3 L/m³. Further research regarding water quality and silkworm colony outcome is needed to understand this phenomenon. Regarding catfish production, the lower FCR leads to a lower feed cost. Feed cost has the most significant proportion in aquaculture activity, which could exceed 60% of the total cost [7]. With the lower FCR in the silkworm-catfish integrated pond, the amount of commercial feed needed could be reduced by up to 30% compared to the conventional method. This condition will lead to a higher profit the farmer receives (Table 2).

Table 1: *Frequency of water flow, silkworm production, catfish production, and catfish's FCR value in some farmers*

Location	Farmers	Flow Frequency	Silkworm culture area (m^2)	Silkworm production (Liter/day)	Catfish Production (kg)	Catfish FCR
Salam Hamlet	Farmer 1 (Joko)	Every 3 days	600	4-7	333	0.90
Salak Malang Hamlet	Farmer 2 (Haryanto)	Every time (continuous flow)	800	8	92	0.82
	Farmer 3 (Joyo)	Every time (continuous flow)	200	6	78	0.77

Table 2: *the detail of cost and profit of catfish culture*

Location	Farmers	Seedling cost (Rp)	Feed cost (Rp)	Revenue (Rp)	Profit (Rp)
Salam Hamlet	Farmer 1 (Joko), 18 m^2	570,000	4,021,000	6,883,500	2,292,500
Salak Malang Hamlet	Farmer 2 (Haryanto), 6 m^2	190,000	912,500	1,780,500	678,000
	Farmer 3 (Joyo), 6 m^2	190,000	730,000	1,447,500	527,500

Thus, water flow from the silkworm cultivation area can be an additional feed source for catfish to reduce the need for commercial feed. With this technology's application, silkworm production required to produce catfish seed in Banjarharjo Village is still fulfilled. Fish-based protein from catfish will also be accessible to the silkworm farmer and the local community.

4 Conclusions

The integration of silkworm and catfish pond provide benefits to the local community. The mutualism symbiosis between silkworms and catfish guaranteed the sustainability of silkworm production and the efficiency of catfish aquaculture. Besides the profit from the daily silkworm production, the lower catfish's FCR also provides better profit for the fish farmer. Hence, the application of this technology proves that silkworm production required to produce catfish seed in Banjarharjo Village is still fulfilled. At the same time, fish-based protein from catfish will also be accessible to the silkworm farmer and the local community. For further research, it is recommended to analyze the water quality and the silkworm colonies' performance from the integrated pond that has high productivity.

5 Declarations

5.1 Study Limitations

This study did not precisely calculate the amount of silkworm colonies carried to the catfish pond during the water recirculation.

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5.4 Competing Interests

The authors declare no competing interests.

5.5 Publisher's Note

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