Growth of Catfish *Clarias gariepinus* (Burchell, 1822) under Different Rearing Methods and Feed Types

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**Abstract.** Inadequate protein intake results in stunting and wasting in children as well as cause health problems at all ages. Proteins from fish excel in promoting children's growth and family health. Consuming catfish has the potential to improve family nutrition because of its affordability, ease of being raised, and dense contents of proteins and beneficial fats. This study aimed to compare the growth of catfish raised in concrete ponds and buckets and also to compare catfish fed with probiotic-fortified and regular feeds. The concrete pond was stocked with 300 juveniles, whereas 80 juveniles each were placed in two buckets. The experiment lasted for 12 weeks. Probiotic feed was given twice a day. After six weeks, probiotic feed in one of the buckets was replaced with regular feed. Body length and weight were assessed once per week with 10-20% samples of the population. Data were analyzed statistically with two-way ANOVA and post hoc Duncan (α=0.05). Catfish raised in buckets can grow similarly to ones reared in concrete ponds with a suitable ratio of fish to water volume and proper care. Probiotic feed increased catfish growth rate. However, there was no significant difference after replacing probiotic feed with regular feed.

**1 Introduction**

Stunting and wasting (S&W) is a global health problem, especially in developing countries, including Indonesia. The phenomenon of S&W occurs in children under the age of five due to long-term undernutrition of protein and micronutrient deficiencies, resulting in impaired growth and development [1]. Therefore, the Indonesian government develops a national strategic plan by which adopting WHO target of reducing the prevalence of S&W by 40% in the period of 2010-2025 [2]. The main risk factors for S&W are insufficient intake of protein, zinc, and family economic status. Children who receive low levels of protein intake have a greater risk of developing S&W [3]. Animal-sourced protein intake can prevent S&W due to its essential amino acid content. However, it costs more than a plant-based protein source [4]. Catfish (*Clarias* sp.) is a freshwater fish commodity with a fairly high protein content, which is approximately 15.82% [5,6]. In addition, catfish is easy to cultivate, even in a limited space, does not require much water, and the price is relatively affordable [7].

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Catfish can survive in the dry season and hot weather; therefore, it is suitable to raise in Indonesia and can be relied upon in conditions of food scarcity [8].

Various efforts have been made to increase production in catfish farming (aquaculture), one of which is by modifying feed with high-quality nutrients [8] or enriching probiotics in the feed [9]. Probiotics contain various enzyme-producing bacteria functions to break down complex compounds into simpler ones, thus facilitating the digestion and absorption of nutrients in the fish digestive tract [9,10]. The supplementation of probiotics to commercial regular feed increases growth rate and feed efficiency [10]. In addition to be reared in the conventional way (earthen pond), catfish can be raised in concrete or tarpaulin ponds, plastic tanks, and even in buckets or budikdamber systems [7, 11]. The budikdamber method is very suitable for households that do not have a wide yard. Dumbo catfish farming following the budikdamber method showed 66.66% survival with an average body length of 15.21 cm and body weight of 87.94 g [12]. In addition to catfish farming, the budikdamber method allows for cultivating various vegetable plants on the bucket lid. Water, as the habitat for catfish, provides nutrients required by plants. With this aquaponic concept, adequate animal protein and the benefits of vegetables are obtained simultaneously [13]. The implementation of budikdamber of Sangkuriang catfish has been successfully carried out to meet protein sufficiency in households in Bandung [14].

This study aimed to compare the growth rate in Mutiara catfish with variations in rearing sites (in concrete ponds vs budikdamber) as well as variations in feed types (standard feed vs probiotic-fortified feed). The outcome of this study is to provide additional insight for aquaculture practitioners and the general public regarding the development of household-scale catfish farming methods to fulfill family nutrition status, especially protein, to support growth and development in early childhood for anticipating the occurrence of S&W.

2 Research Method

2.1 Research Location and Time

This research was carried out from July to October 2023 at Biodiversity Research Station II, Faculty of Biology, Universitas Gadjah Mada, located in Pedukuhan Manggung, Kelurahan Caturtunggal, Kecamatan Depok, Kabupaten Sleman, Provinsi Daerah Istimewa Yogyakarta, 55281.

2.2 Tools and Materials

The experimental animals were 400 juveniles of Mutiara catfish with body lengths of 7-9 cm (Sentra Bibit Lele Le’ KaBrAs Yogyakarta). Catfish feed was standard pellet (Hi-Pro-Vite pellets, P.T. Central Pangan Pertiwi, Karawang) with #781-2 (the initial production) and #781-3 (the finisher). The probiotic solution was prepared by Mr. Paulus Hendro Priatmoko (Sentra Bibit Lele Le’ KaBrAs Yogyakarta).

Catfish are reared in a concrete pond with a volume of 200 L and two buckets with a volume of 80 L. Buckets were modified for rearing catfish (budikdamber). Water for the maintenance of catfish was sourced from a pump well in the research location. To anticipate catfish jumping from the rearing site as well as to reduce excessive heat from the sun, the pond and buckets were covered with paranet (Figure 1).
Fig. 1. Variation of rearing place and feeding type. CP= Concrete pond for raising catfish fed with probiotic feed, BPP= bucket for raising catfish fed with probiotic feed, BPN= bucket for raising catfish fed with probiotic feed for six weeks then replaced with non probiotic/regular feed

Tools for collecting data consisted of laminated millimeter block paper, a ruler, and a digital scale (Camry® EK3650). Tools for measuring water quality were: air thermo-hygrometer (type KT-908®), water thermometer (type TP-300®), pH meter (type PH-009®), and TDS & EC meter (type EZ-1®).

2.3 Stocking of catfish juveniles and initial rearing

For 24 hours before stocking, the pond and buckets were filled with water; then foliage was added to create "green water." Each bucket was filled with 80 juvenile catfish, and the rest were put into the concrete pond. Catfish were fed with probiotic feed twice a day, in the morning and evening. Ponds and buckets were drained twice a week by removing 30-50% of dirty water and then adding clean water.

2.4 Probiotic-fortified feed preparation and feeding method

Probiotic feed is a mixture of standard feed and probiotic solution. A total of 50 mL of probiotic solution was dissolved into 1.5 L of water, then poured on 7.5 kg of standard pellets little by little, mixed until evenly distributed. Probiotic feed was stored in a clean container, tightly closed, and placed in the shade to prevent from exposed to direct sunlight. Both catfish reared in ponds, and buckets were fed with probiotic feed twice a day for six weeks. At week 7, probiotic feeding in one of the buckets was stopped and replaced with standard feed (without probiotic) until week 12.

2.5 Data collection

Measurement of body length (cm) and body weight (g) were conducted after the condition of catfish juveniles stabilized, i.e. after no massive mortality was found (stated as week 1). Measurements were taken once a week based on the random sampling method, with a sample size of 10% of the population in each bucket and 20% of the population in the pond.
2.6 Water quality measurement

Measurements were taken twice a day, in the morning and evening, before catfish were fed. Water quality parameters include temperature (°C), acidity (pH), total dissolved solids (TDS, ppm), and electrical conductivity (EC, μS/cm). In addition, air temperature (°C) and relative humidity (%) were also measured.

2.7 Data analysis

Data on catfish growth and water quality were tabulated in Microsoft® Excel® v.2016. Data on catfish growth were then analyzed statistically based on order-2 polynomial regression to determine whether there were effects of variation in rearing site and type of feed on catfish growth rate. A two-way ANOVA test followed by Duncan's post hoc (α=0.05) was also conducted to determine whether there were significant differences between groups and between times as well as the interaction between treatment type and growth rate using IBM® SPSS® v.25. Water quality data were presented as a range of minimum to maximum.

3 Result and Discussion

3.1 Result

The comparison of body length and weight of catfish under different rearing methods and feed types were visualized in Figure 2.

![Figure 2](https://example.com/fig2.png)

**Fig. 2.** Body length (left) and weight (right) of catfish under different rearing methods and feed types. CP= catfish were reared in the concrete pond, fed with probiotic feed, BPP= catfish were reared in the bucket, fed with probiotic feed, BPN= catfish were reared in the bucket, fed with probiotic feed for six weeks, then replaced with nonprobiotic/regular feed.

<table>
<thead>
<tr>
<th>Group</th>
<th>Body length (cm)</th>
<th>R²</th>
<th>Body weight (g)</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Equation</td>
<td></td>
<td>Equation</td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td>( y = -0.0213x^2 + 0.9831x + 13.665 )</td>
<td>0.9815</td>
<td>( y = -0.0279x^2 + 5.426x + 16.891 )</td>
<td>0.9523</td>
</tr>
<tr>
<td>BPP</td>
<td>( y = -0.0609x^2 + 1.341x + 12.576 )</td>
<td>0.8410</td>
<td>( y = -0.3041x^2 + 8.2821x + 11.454 )</td>
<td>0.8261</td>
</tr>
<tr>
<td>BPN</td>
<td>( y = -0.0326x^2 + 1.0121x + 13.979 )</td>
<td>0.9356</td>
<td>( y = -0.0702x^2 + 5.7375x + 18.699 )</td>
<td>0.9248</td>
</tr>
</tbody>
</table>

Note: CP= catfish were reared in the concrete pond, fed with probiotic feed, BPP= catfish were reared in the bucket, fed with probiotic feed, BPN= catfish were reared in the bucket, fed with probiotic feed for six weeks, then replaced with nonprobiotic/regular feed.
Catfish reared in different sites with different feed types showed relatively similar body length and weight trends. This statement is confirmed by the result of order-2 polynomial regression analysis, as shown in Table 1.

Through R squared ($R^2$) value, it can be seen that the growth of catfish followed the normal biological growth curve (sigmoid). All $R^2$ values are closer to 1.0, indicating that data conform to the regression line. Catfish in the BPP group have the lowest growth rate compared to other groups. However, $R^2$ value of more than 0.8 is still considered a good fit for normal growth. Based on visualization in Figure 1 and $R^2$ values in Table 1, variations in rearing sites and feed types did not seem to affect catfish growth. To confirm this, statistical analysis was carried out based on the two-way ANOVA method (Table 2).

Table 2. The result of two-way ANOVA followed by Duncan’s post hoc test ($\alpha=0.05$) of body length and weight of catfish under different rearing methods and feed types

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F ratio</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body Length (cm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td>207.544</td>
<td>2</td>
<td>103.772</td>
<td>11.284</td>
<td>0.000*</td>
</tr>
<tr>
<td>Measurement</td>
<td>5285.099</td>
<td>12</td>
<td>440.425</td>
<td>47.892</td>
<td>0.000*</td>
</tr>
<tr>
<td>Interaction</td>
<td>399.811</td>
<td>24</td>
<td>16.659</td>
<td>1.811</td>
<td>0.010*</td>
</tr>
<tr>
<td>R squared = 0.420 (Adjusted R squared = 0.399)</td>
<td>MS (Error) = 9.196</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F ratio</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body Weight (g)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td>2110.056</td>
<td>2</td>
<td>1055.028</td>
<td>1.404</td>
<td>0.246</td>
</tr>
<tr>
<td>Measurement</td>
<td>321782.349</td>
<td>12</td>
<td>26815.196</td>
<td>35.696</td>
<td>0.000*</td>
</tr>
<tr>
<td>Interaction</td>
<td>25747.107</td>
<td>24</td>
<td>1072.796</td>
<td>1.428</td>
<td>0.083</td>
</tr>
<tr>
<td>R squared = 0.338 (Adjusted R squared = 0.314)</td>
<td>MS (Error) = 751.221</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The body length of catfish reared in buckets was significantly shorter than those in ponds. However, body weight measurements showed there was no significant difference between catfish in buckets and those in ponds. Both catfish in buckets and ponds experienced significant increases in body length and weight over time. Discontinuing probiotic feeding in week 6 reduced the rate of increase in catfish body weight, however it was not significant. Beside comparing growth rate of catfish, water quality parameters were also recorded to support the discussion. The results are shown in Table 3.

Table 3. Comparison of water quality of catfish reared under different rearing methods and feed types

<table>
<thead>
<tr>
<th>Group</th>
<th>T (°C)</th>
<th>pH</th>
<th>TDS (ppm)</th>
<th>EC (µS/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP</td>
<td>25.5 – 29.1</td>
<td>6.6 – 7.6</td>
<td>292 – 495</td>
<td>592 - 990</td>
</tr>
<tr>
<td>BPP</td>
<td>26.3 – 33.9</td>
<td>6.8 – 7.4</td>
<td>312 – 1156</td>
<td>630 - 2312</td>
</tr>
<tr>
<td>BPM</td>
<td>25.7 – 32.6</td>
<td>6.6 – 7.4</td>
<td>216 – 1038</td>
<td>430 - 2076</td>
</tr>
</tbody>
</table>

Note: CP= catfish were reared in the concrete pond, fed with probiotic feed, BPP= catfish were reared in the bucket, fed with probiotic feed, BPN= catfish were reared in the bucket, fed with probiotic feed for six weeks, then replaced with nonprobiotic/regular feed. T= temperature, pH= acidity, TDS= total dissolved solids, EC= electrical conductivity.
Based on Table 3, it can be seen that the temperature in buckets was higher than in pond. Meanwhile, the pH value in buckets was relatively similar to that in the pond. Probiotic feeding did not affect the water quality in bucket, as indicated by relatively similar pH, TDS, and EC values. The range of temperature, TDS, and EC in buckets were higher than in the pond due to the difference in volume and materials (plastic vs concrete).

3.2 Discussion

3.2.1 Body Length and Weight

Based on the data in Table 3, it was demonstrated that the body size of catfish reared in buckets was significantly shorter than those in ponds, whereas there was no significant difference in body weight between two habitats. It means that catfish in buckets and ponds have relatively similar body weights. However, catfish from the pond have longer body sizes than those in buckets. The catfish in the pond are darker than those in buckets as a result of the background color adaptation mechanism toward their habitat (Figure 3).

Fig. 3. Comparison of catfish samples from the pond (CP) and buckets (BPP and BPN). CP= catfish were reared in the concrete pond, fed with probiotic feed, BPP= catfish were reared in the bucket, fed with probiotic feed, BPN= catfish were reared in the bucket, fed with probiotic feed for six weeks, then replaced with nonprobiotic/regular feed.

With the same body weight but different body length, it can be determined that the body shape, and further, the meat ratio of catfish from the bucket are more than those from the pond. In terms of rearing for protein sufficiency, therefore catfish from the buckets are more desirable due to the meat content. Catfish meat contains the highest protein and complete amino acids compared to broiler chicken as the common protein source in Indonesia [6,15]. Our findings align with research conducted on catfish farming in Nigeria, which found that variation in rearing sites resulted in catfish with different body lengths and weights. These variations impact the nutrient content in proximate analysis [16].

3.2.2 Growth Rate

Based on Table 1, it was found that the fastest growth rate of catfish occurred in the pond, followed by those in buckets. Unexpectedly, catfish that were continuously given with probiotic feed actually had the slowest growth rate. Regression is not a determinant in the comparison of probiotic proficiency, one of which is because there was a bias in the initial
rearing method. In this experiment, we did not do grading or selection for body size consistency in the catfish population, which could have contributed to growth rate variances [17]. The growth rate in fish is influenced by several factors, one of which is the environmental conditions. In this case, there are variations of rearing sites, i.e., pond vs bucket. The fastest growth rate of catfish in pond can be explained by the wider volume, which has a direct effect on the growth rate of catfish, indicated by longer body size and weight gain of catfish [18]. Another finding from the growth rate observation is that there was a significant decrease in body length and weight and length of catfish in weeks 10-11, especially in catfish that were continuously given with probiotic feed. In Indonesia, catfish that are intended for consumption are ideally harvested when they reach a number of 8-10 per kilogram or approximately 100-125 grams in weight [19]. Allowing large catfish in ponds or buckets will suppress the growth of smaller ones due to the competition for food.

3.2.3 Competition and Adaptation

Differences in fish movement adaptation are influenced by competition during feed consumption and habitat [20,21]. Fish in ponds tend to move faster than fish in buckets because the pond has a wider area or volume compared to the bucket. Fish in the pond were free to swim around and explore more, this resulted in adaptation or modification in their physical characteristic to be significantly longer than those in the buckets.

3.2.4 Water Quality Parameters

Water quality greatly determines the growth of catfish in the budikdamber system. Since the Budikdamber method lacks active water flow, aeration, and filtration, the water quality quickly declines. Therefore, water changes must be done regularly [22]. The water temperature in both buckets is relatively higher than in the pond. This phenomenon may occur due to the different habitat volumes and materials that construct them. The buckets in this experiment have a capacity of 80 L each. Meanwhile, the pond's volume is significantly larger, with a capacity of 200 L. The smaller volume of buckets allows the water inside to heat up much faster, and with the addition of the fact that the buckets are made out of plastic. Plastic acts as an excellent insulator that can retain heat better than most insulators, including concrete, which is the main material of the pond [23]. In the context of the experiment, heat transferred from sunlight, and catfish activity will be kept better in buckets rather than pond. Measurement of pH levels shows stable values in buckets and ponds, implying that feed and remaining feed that may be present, as well as metabolic waste from catfish raised in buckets, did not reduce the water quality. The pH of the water becomes low (acidic) due to animal respiratory activity (carbon dioxide), urination (nitrogen metabolism waste), and decomposition of organic materials such as remaining feed, dead animals, microbial activity, etc.

On the other hand, the pH of water increases (alkaline) along with increasing temperature as well as the levels of carbonate and bicarbonate originating from animal excretory activities [24]. The level of TDS and EC were also measured in order to quantify nitrogen build-up in the form of ammonia, organic particles, inorganic salts, and ions excreted by catfish [25]. Results showed that TDS and EC values between buckets and pond are relatively similar. However, buckets have a wider range in comparison to that in the pond, which implies a higher concentration of solutes in buckets. This phenomenon is expected to happen due to the different ratios of volume and temperature between buckets and ponds, which means the ratio of catfish excrement to water is larger in buckets rather than in ponds. The significant amount of carbon dioxide, nitrogen, and salinity, as well as high temperature, impacts the dissolved oxygen (DO) level in the habitat [26]. Fortunately, catfish is regarded as a fish
species highly tolerant to low levels of DO. They develop a structure and a mechanism to breathe using a modified gill structure, the arborescent organ, which increases their resistance to low-oxygen environments [27]. Excessive feeding to fish causes elevated nitrates and phosphates, which can reduce water quality [28]. Adding probiotics in feed can increase fish growth rate. Microorganisms such as *Bacillus megaterium*, *B. subtilis*, *Lactobacillus acidophilus*, *L. bulgaricus*, and *Saccharomyces cerevisiae* increase the activity of digestive enzymes, thereby increasing their growth rate. However, microbial content in leftover feed can potentially increase solutes in the water, thereby reducing water quality [29]. According to the data, water quality parameters are proven to be stable in exposure to probiotic feed, which signifies that probiotic feed does not affect water quality both in buckets and ponds.

Our data proved that catfish can be raised both in buckets and ponds by considering the ratio between the number of catfish and the volume of water. As a result, we recommend *budikdamber* method for households that lacking large yard. An additional advantage of catfish farming through *budikdamber* is that it takes only roughly three months for the fish to be ready for harvest and consumption [30].

### 4 Conclusion

Catfish raised in buckets (*budikdamber*) can grow well, similarly to those reared in concrete ponds, with a suitable proportion of fish to water volume and appropriate care. Catfish from *Budikdamber* have shorter bodies but normal body weight. Probiotic feeding optimizes the growth rate of catfish. Discontinuing probiotic feeding reduced the rate of body weight gain but not significant. If continued, it could decrease significantly due to the difference of nutritional content between regular feed and probiotic feed. Based on these findings, we recommend *budikdamber* system as a solution to animal protein adequacy in household scale, particularly to anticipate the occurrence of stunting and wasting in children.

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