Substitution of commercial feed with fermented banana peel flour (Musaceae sp.) and fish meal to feed consumption level, specific growth rate, feed efficiency, fat retention, and energy retention in siam catfish (Pangasius hypophthalmus)

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Abstract. This study aims to investigate the effect of commercial feed substitution with fermented banana peel flour and fish meal on feeding rate, specific growth rate, feed efficiency, fat and energy retention. This study used a Completely Randomized Design which consisted of 5 treatments: P0 (100% commercial feed), P1 (commercial feed 95% + 5% FTKPTI), P2 (commercial feed 90% + 10% FTKPTI), P3 (commercial feed 85% + 15% FTKPTI), and P4 (commercial feed 80% + 20% FTKPTI). Data were analyzed using Analysis of Variance (ANOVA) and continued with Duncan's Multiple Range Test. The results of statistical analysis showed that commercial feed substitution using fermentation of banana peel flour (Musaceaeae sp.) And fish meal resulted in feed consumption values, specific growth rates, feed efficiency, fat retention and energy retention which had no significant differences (p> 0.05). This shows that commercial feed substitution using fermentation of banana peel flour (Musaceaeae sp.) and fish meal up to a dose of 20% in feed has the same feed consumption, specific growth rate, feed efficiency, fat retention and energy retention values as well as the control feed.

1. Introduction

Siam catfish (P. hypophthalmus) is a freshwater fish species from the Pangasidae family and is one of the fish species with economic value for cultivation. Siam catfish originated from Thailand in 1972 and began to be widely cultivated in Indonesia in 1985 [1]. In 2011, Indonesia's catfish production reached 229,267 tons, with a contribution of 16.11% of world catfish production [2]. Siamese catfish has the advantage of not having many spines, high fecundity, and survival rate can be mass-produced and has opportunities for industrial-scale development. With these advantages, this fish has become one of the fisheries commodities with high economic value, both in the hatchery business segment and in the rearing business [3]. Increasing catfish production through cultivation activities requires increased production input, one of which is feed.

The feed is one of the critical factors that affect the growth and survival of cultivated fish. According to Centyana et al. [4] stated, fish farming is strongly influenced by sufficient feed availability to support maximum quality. The cost of commercial feed in Siamese catfish cultivation can reach 60-70% of the
production cost. Thus, it is necessary to manage alternative feed that is effective and efficient and reduce production costs. One of the alternative materials derived from agricultural waste is banana peels.

Banana plants (Musaceaea sp.) are a type of tropical plant that is very much produced in Indonesia. As a raw material for fish feed, banana peels contain 7.26% protein, 15.29% fat, and 24.13% crude fiber [5]. Vegetable materials generally contain crude fiber, which is difficult to digest because it has a strong cell wall so that it is difficult to crack [6]. One of the efforts to reduce banana peels' crude fiber content is to carry out biological fermentation using cellulolytic microbes [7]. Fermentation is a process of changing organic matter both physically, chemically, and biologically from a complex structure to a simpler one, thereby increasing livestock digestibility [8]. Fermentation is carried out with the help of probiotics. The probiotics used in the fermentation of banana peel flour are commercial probiotics containing the microbes Enterobacter spp., Cellulomonas spp., and Actinomyces spp., which are cellulolytic [30].

The crude protein content of banana peel flour is too low, namely 5.15% [5]. Fish meal is needed to equalize banana peel flour's protein fermentation with commercial feed to make it easier to do the substitution. Fish meal is a source of animal protein that is widely used in the manufacture of fish feed. Fish meal contains 57% crude protein, 9% crude fat, 4% crude fiber, and 4% ash content [9].

Fish feed consumption is a measure of the need for a fish population for its feed source. Feed consumption can increase oxygen consumption. This increase in metabolic rate affects fish growth [10]. Growth is a change in size, length, or weight over time. Growth is closely related to feeding. The quality feed contains constituent components, including protein, fat, carbohydrates, minerals, and vitamins. Feed efficiency is the ratio between body weight gain and the amount of feed given during maintenance. Higher feed efficiency indicates an efficient use of feed [11]. It is hoped that the substitution is to save on feed costs in catfish culture and minimize the high-fat content of the meat because fermentation of banana peel flour has a high crude fiber content. High-fat content causes meat characteristics to be soft [12]. The presence of fat in the body of fish is essential for cellular needs as an energy source. Still, the presence of fat that is not balanced with protein content and feed energy availability can affect performance [12].

Energy is obtained from overhauling chemical bonds through an oxidation reaction process of feed components, namely protein, fat, and carbohydrates, into simpler compounds (amino acids, fatty acids, and glucose) so that the body can absorb them for use or storage [13]. Evaluation of feed energy utilization by catfish can be seen from fat retention and energy retention. Based on this background, it is necessary to research commercial feed substitution using fermentation of banana peel flour and fish meal, which is expected to positively affect the level of feed consumption, specific growth rate, feed efficiency, fat retention and energy retention in siam catfish, and can produce quality and quality. Feed yields the same as commercial feed, but the price is more affordable.

2. Material and methods
2.1. Material
The tools used in this study were 20 aquariums with a size of 50x30x30 cm³, 1 reservoir, aerator, aerated stone, hose, seser, siphon, ruler, milling, pelletizer, thermometer, pH paper, DO meter, ammonia test kit, sample pot, digital scale, plastic clip, 1 kg plastic bag, basin, jar, oven, spoon and label paper.

The animal that will be used in this research is the siam catfish (P. hypophthalmus) in size of 9-12 cm obtained from BBI Puri Mojokerto. Each aquarium contains 10 tilapia fish for a total of 200 fish. The materials used in this study were fermented banana peel flour, fish meal, commercial feed, Aquades, BioMC4 probiotics, molasses. Banana peels are obtained from processed banana traders on Tegalsari Street, Surabaya, East Java.

The research was carried out from February to April 2020 which is located at the Anatomy and Cultivation Laboratory of the Faculty of Fisheries and Marine, Universitas Airlangga, Surabaya. Proximate analysis was carried out at the Service Unit for the Consultation and Training Laboratory for the Veterinary Testing and Feed Analysis Unit, Faculty of Veterinary Medicine, Universitas Airlangga, Surabaya. The method used in this study is an experimental method using a Completely Randomized
Design (CRD) consisting of 5 treatments with 4 repetitions each, there was $P_0 = 100\%$ Commercial feed + $0\%$ FTKPTI, $P_1 = 95\%$ Commercial feed + $5\%$ FTKPTI, $P_2 = 90\%$ Commercial feed + $10\%$ FTKPTI, $P_3 = 85\%$ Commercial feed + $15\%$ FTKPTI, $P_4 = 80\%$ Commercial feed + $20\%$ FTKPTI. FTKPTI is a combination of fermented banana peel flour and fish meal with a ratio of 1:2.6 to obtain a protein content equivalent to commercial feed.

2.2. Method

2.2.1. Produced of fermented banana peel flour

The banana peel that has been obtained is separated from the stump, then cut ± 2-3 cm and dried banana peel for ± 3-7 days. After drying, the banana peel ground until smooth into flour. In fermentation of 100 grams of banana peel flour, it is necessary to add 22 ml of distilled water, 3 ml of molasses, and 5 ml of BioMC4 probiotic. All ingredients are mixed until homogeneous, then put in plastic and fermented for 7 days under anaerobic conditions.

2.2.2. Preparation of siam catfish feed

The feed ingredients such as fermented banana peel flour, fish meal, and commercial feed were analyzed proximate first. Before the substitution, the results of the proximate analysis of protein content in fermented banana peel flour added with the fish meal were equivalent to the protein content of the commercial feed. The commercial feed of siam catfish is mashed and then sieved to produce a soft material before being combined with a fermented mixture of banana peel flour and fish meal according to the calculated treatment dose. The feed ingredients that have been mixed homogeneously and then printed using a pellet press. After that, pellets are dried for 1 day. The dried pellets are stored in a plastic clip bag and labelled, stored in a dry place.

2.2.3. Aquarium preparation

Aquarium used was 50x30x30cm³ with 20 pieces. Before use, the aquarium is first cleaned and sterilized. The cleaning process is done by washing using clean water and chlorine. Culturing media for the fish are using freshwater which has been aerated for one day to increase the oxygen content dissolved in water.

2.2.4. Fish culture

The fish used in this study were siam catfish (P. hypophthalmus) size 9-12 cm. Each aquarium is filled with 10 fish. The acclimatization process is carried out first to adjust the physiology of the fish with culturing media. Total feeding was 3% of the weight of fish biomass with the frequency of giving 2 times per day.

2.2.5. Data collection

The main parameters observed in this study were the level of feed consumption, specific growth rate, feed efficiency, fat retention and energy retention in siam catfish meat. Analysis of feed consumption level, specific growth rate, feed efficiency, fat retention, and energy retention was carried out at the beginning of the experiment and the end of the experiment to compare the effects of each treatment. Parameters for the level of feed consumption, growth rate, and feed efficiency were obtained from the feed given according to the feed needs of Siamese catfish, namely 3% of the fish weight during 28 days of maintenance, then sampling was carried out every 7 days to analyze the weight gain of the fish. The parameters of fat retention and energy retention were obtained after maintaining the Siamese catfish that were fed treated feed. The bodyweight of the catfish was measured at the beginning and the end of the maintenance, after that the catfish meat was filled in, the samples that had been weighed were then put into the sample pot, labelled according to the treatment, and packed in styrofoam.

a. Feed Consumption (FC)

The calculation of the level of feed consumption was:
FC = F1 - F2
Description:
FC = level of feed consumption (grams)
F1 = total weight of initial feed (grams)
F2 = weight of leftover feed (grams)

b. Specific Growth Rate (SGR)
Specific daily growth is calculated based on the formula:

\[ SGR = \frac{\ln Wt - \ln Wo}{t} \times 100\% \]

Description:
SGR = Specific growth rate (%)
Wt = Average weight of fish at the end of the experiment (grams)
Wo = Average fish weight at the beginning of the experiment (grams)
t = Time during the experiment (days)

c. Feed Efficiency (EP)
The efficiency of feed utilization is calculated based on the formula:

\[ EP = \frac{(Wt + D) - Wo}{F} \times 100\% \]

Description:
EP = Feed efficiency (%)
Wt = Average weight of fish at the end of the experiment (grams)
Wo = Average fish weight at the beginning of the experiment (grams)
D = Weight of dead fish (grams)
F = Amount of feed consumed (grams)

d. Fat Retention
According to Watanabe et al. [14], the fat retention value can be calculated by the following formula:

\[ \text{Fat Retention} = \frac{(\text{final body fat weight} - \text{initial body fat weight}) \times 100\%}{\text{Feed BK} \times \text{Feed fat content} \times \text{Total feed consumption}} \]

Calculation of fat retention of siam catfish is done by:

Initial body fat weight = initial body BK (%) \times initial body fat content (%) \times initial body weight of fish (g)
Final body fat weight = final body weight gain (%) \times final body fat content (%) \times final body weight of fish (g)

e. Energy Retention
Meanwhile, energy retention according to Watanabe et al. [14] can be calculated with the following formula:

\[ \text{Energy Retention} = \frac{(\text{final body energy weight} - \text{initial body energy weight}) \times 100\%}{\text{Feed BK} \times \text{Feed energy content} \times \text{Total feed consumption}} \]

The calculation of the energy retention of siam catfish is done by:
Initial body energy weight = initial body BK (%) × Initial body energy (%) × initial body weight of fish (g)
Final body energy weight = final body weight gain (%) × final body energy t (%) × final body weight of fish (g).

2.3. Data analysis
The data obtained were analyzed using the Statistical Product and Service Solution (SPSS). Analysis of the data used is Analyze of Variance (ANOVA) to determine the effect of the treatment given if there are significant results, the calculation is continued with the Duncan Multiple Range Test.

3. Result and discussion
3.1. Feed consumption rate
Data on the average level of feed consumption of siam catfish are shown in Table 1. The results of statistical calculations using Analysis of Variance (ANOVA) show that there is no significant difference (p > 0.05) on the level of feed consumption of siam catfish.

| Treatment | Feed Consumption Level ± SD |
|-----------|----------------------------|
| P0        | 47.04 ± 1.09               |
| P1        | 47.40 ± 1.40               |
| P2        | 47.44 ± 1.35               |
| P3        | 47.52 ± 1.35               |
| P4        | 46.87 ± 0.90               |

Description : SD = Standard Deviation, P0 (100% Commercial Feed + 0% FTKPTI), P1 (95% Commercial Feed + 5% FTKPTI), P2 (90% Commercial Feed + 10% FTKPTI), P3 (85% Commercial Feed + 15% FTKPTI), P4 (80% Commercial Feed + 20% FTKPTI).

The value of the feed consumption level is calculated from the amount of feed given minus the remaining feed that is not consumed during the maintenance period. The nutritional value in each feed composition, which is almost the same, can be a factor in feed consumption level, which is not significantly different. This is by Razak et al. [15] that the protein and energy content of feed that is in a balanced state in each treatment feed will result in the same feed consumption as it is known that the balance of protein and energy is very influential on the amount of feed consumption. According to Indriyanti [16], the energy level in the feed will determine the amount of feed consumed; in addition to the energy factor in feed, the tendency of crude fiber in feed can also affect the level of consumption, namely the higher the crude fiber it will provide a feeling of fullness because the composition of complex carbohydrates stops appetite. It is resulting in reduced feed consumption.

According to Sekar [17], siam catfish are very responsive to artificial feed and convert feed better than other cultivated fish types. The feed provided meets the protein and energy needs for the metabolic activity of its body tissues. Substitute commercial feed using fermented banana peel flour and fish meal can be well received by the siam catfish. Because according to the nutritional needs of siam catfish, according to Putra et al. [18], where the protein content ranges from 25-30%, the maximum fat content is 5%, and the crude fiber content is a maximum of 8%. Meanwhile, the nutritional content contained in the P4 treatment with a dose of 20% FTKPTI had 39.729% protein content, 6.041% crude fat, and 4.365% crude fiber. Therefore, this alternative feed can be well received by the siam catfish, although it does not significantly affect feed consumption level.
3.2. Specific growth rate
The average specific growth rate data for siam catfish are shown in Table 2. The results of statistical calculations using Analysis of Variance (ANOVA) show no significant difference (p > 0.05) to the specific growth rate of siam catfish.

| Treatment | Specific Growth Rate ± SD | Specific Growth Rate (Transformation arcsin ± SD) |
|-----------|---------------------------|-----------------------------------------------|
| P0        | 1.32 ± 0.39               | 6.55 ± 1.01                                   |
| P1        | 1.33 ± 0.28               | 6.59 ± 0.71                                   |
| P2        | 1.46 ± 0.41               | 6.88 ± 1.00                                   |
| P3        | 1.51 ± 0.55               | 6.95 ± 1.36                                   |
| P4        | 1.70 ± 0.21               | 7.47 ± 0.47                                   |

Description: SD = Standard Deviation, P0 (100% Commercial Feed + 0% FTKPTI), P1 (95% Commercial Feed + 5% FTKPTI), P2 (90% Commercial Feed + 10% FTKPTI), P3 (85% Commercial Feed + 15% FTKPTI), P4 (80% Commercial Feed + 20% FTKPTI).

Fish growth is an indicator of fish farming; the faster fish grow, the higher the fish farming efficiency. The results of statistical tests (ANOVA) for commercial feed substitution using fermentation of banana peel meal and fish meal showed no significantly different (p > 0.05) on the specific growth rate of siam catfish. In the treatment P0 (0% FTKPTI), P1 (5% FTKPTI), P2 (10% FTKPTI), P3 (15% FTKPTI), and P4 (20% FTKPTI) showed the same specific growth rate of siam catfish.

Growth is influenced by dietary nutrients such as protein; the higher the protein content in feed ingredients, the more expensive the operational costs for cultivation are [19]. This study's treatment had an increasing dose of fermentation of banana peel flour and fish meal (FTKPTI), but the protein content in feed remained at 39.729%. This shows that up to 20%, the addition of FTKPTI in feed substitution can reduce the cost of purchasing feed.

The energy values that can be digested in the feed treatment P0, P1, P2, P3, and P4 show relatively the same energy values. At the 20% level, FTKPTI contains the energy of 2565.53 Kcal/kg, but the protein content is still 39.729%. The lower energy in feed content resulted in higher protein in-feed content. Therefore the protein and energy content in the treated feed shows a balance. According to Guo et al. [20], the balance of protein and energy in feed is essential to optimize the use of protein for fish growth and maximize fat and carbohydrates as an energy source.

3.3. Feed efficiency
Data on the average feed efficiency of siam catfish were shown in Table 3. The results of statistical calculations using Analysis of Variance (ANOVA) showed that there was no significant difference (p > 0.05) on the feed efficiency of siam catfish.

| Treatment | Feed Efficiency ± SD | Feed Efficiency (Transformation arcsin ± SD) |
|-----------|----------------------|-----------------------------------------------|
| P0        | 76.40 ± 11.43        | 61.43 ± 7.88                                  |
| P1        | 78.07 ± 10.54        | 62.57 ± 7.54                                  |
| P2        | 80.00 ± 11.18        | 63.97 ± 7.75                                  |
| P3        | 85.47 ± 9.70         | 68.52 ± 8.32                                  |
| P4        | 86.50 ± 6.20         | 68.82 ± 5.30                                  |
Feed efficiency is the percentage of the weight of fish produced compared to the weight of the feed given. The value of feed efficiency is related to the fish's growth rate. The higher value of fish feed efficiency resulted in better the fish response to feeding, which is indicated by increased growth [21].

The results of statistical calculations (ANOVA) substitution of commercial feed using fermentation of banana peel flour and the fish meal did not give a significant difference (p> 0.05) to the value of the feed efficiency of siam catfish. The absence of differences in feed efficiency in this study was due to feed consumption and specific growth rates, which were not significantly different, thus causing the feed efficiency not significantly different.

According to Fitriyani et al. [22], the feed can be good if the feed efficiency value is more than 50% or even close to 100%. The value of feed efficiency is quite good due to the type of feed ingredients used to produce feed easily digested by siam catfish. One of the factors that affect feed digestibility is crude fiber content [23]. According to Putra et al. [18], 8% crude fiber content for siam catfish nutritional is a maximum. The use of fermented banana peel flour and fish meal with 20% composition given in the treated feed contains 4.365% crude fiber. This shows that the crude fiber content of 4.365% in the feed is still acceptable to the siam catfish.

Other factors that affect feed efficiency are the lack of feed and low quality [24]. The feed efficiency value is used as an indicator to determine the effectiveness of the feed consumed by fish [25]. The less feed is consumed by fish and results in high growth, leading to higher feed efficiency; this is because fish consumption is efficient for becoming meat [26].

According to Utomo et al. [27], increased feed efficiency indicates an efficient use of feed so that only a little protein is changed to meet energy needs, and the rest is used for growth.

### 3.4. Fat retention

The results showed that the fat retention of siam catfish (P. hypophthalmus) ranged from 2.7673% - 3.7568%. This study used a Completely Randomized Design (CRD), furthermore, it used a statistical Analysis of Variance (ANOVA) and there was no significant difference (p>0.05). The average data on fat retention of siam catfish (P. hypophthalmus) can be seen in Table 4.

| Treatment | Fat Retention (%) ± SD | Fat Retention (Transformation (√) ± SD) |
|-----------|------------------------|----------------------------------------|
| P0        | 2.7673 ± 0.76394       | 9.5521 ± 1.35250                       |
| P1        | 3.7568 ± 0.46480       | 11.1594 ± 0.69758                      |
| P2        | 3.0974 ± 0.84228       | 10.0554 ± 1.46798                     |
| P3        | 3.2466 ± 1.36357       | 10.1785 ± 2.37398                     |
| P4        | 3.7448 ± 0.70498       | 11.1182 ± 1.05197                     |

Description : SD = Standard Deviation, P0 (100% Commercial Feed + 0% FTKPTI), P1 (95% Commercial Feed + 5% FTKPTI), P2 (90% Commercial Feed + 10% FTKPTI), P3 (85% Commercial Feed + 15% FTKPTI), P4 (80% Commercial Feed + 20% FTKPTI).

Fat retention describes fish's ability to store and utilize feed fat; therefore, the value of fat retention is obtained from the comparison between the amount of fat stored in the body tissue of the fish and the shape of the composition of the fat consumed by fish [28].

The statistical analysis of commercial feed substitution using fermentation of banana peel flour and the fish meal did not provide real evidence (p> 0.05) on the fat retention of siam catfish in all treatments. The table of average fat retention values of siam catfish shows that in treatment P0 to P1 has increased,
but fat retention of P1 to P2 has decreased and has increased again in treatment P3 and P4 is not in line with the increase in the quality of fat content in the feed used in the study from P0-P4. The high fat retention in treatment P1 (3.7568%) compared to P2 (3.0974%), P3 (3.2466%), P4 (3.7448%) was thought to be caused by crude fiber content in the feed, the crude fiber in feed. P2, P3, and P4 treatments were higher than P1; this disrupted the absorption of nutrients, one of which was fat, because the lack of high crude fiber content in feed made it more difficult for fish to digest feed [29]. Fat retention in P2 (3.0974%), which has decreased as in the average result of fat retention, is thought to be because feed fat is used more as a metabolic source so that less feed fat is absorbed and stored by the fish body. Fat content in feed ranges from 4.96% - 6.041%; this is still by the statement of Afrianto and Liviawaty [13] that most freshwater fish need 4% - 8% fat.

The statistical results were not significantly different because the differences in the fat content of the feed between treatments were not too far away, P0 (4.96%), P1 (5.23%), P2 (5.50%), P3 (5.77%), and P4 (6.04%). This results in the absorption of feed fat by fish that is not different; according to Fahy et al. [31], one of the factors that influence fat retention is the amount of fat in the feed.

3.5. Energy retention
The results showed that the energy retention of siam catfish (P. hypophthalmus) ranged from 2.0904% -3.9694%. This study used a Completely Randomized Design (CRD), furthermore, it used a statistical Analysis of Variance (ANOVA) and there was no significant difference (p> 0.05). The average energy retention data of siam catfish (P. hypophthalmus) can be seen in Table 5.

| Treatment | Energy Retention (%) ± SD | Energy Retention (Transformation (√) ± SD) |
|-----------|---------------------------|--------------------------------------------|
| P0        | 2.0904 ± 0.79281          | 8.1792 ± 1.71440                           |
| P1        | 2.6581 ± 0.25555          | 9.3710 ± 0.46617                           |
| P2        | 3.0487 ± 0.85547          | 9.9803 ± 1.41029                           |
| P3        | 3.5639 ± 1.81334          | 10.4941 ± 3.36154                          |
| P4        | 3.9694 ± 0.72094          | 11.4554 ± 2.00709                          |

Description : SD = Standard Deviation, P0 (100% Commercial Feed + 0% FTKPTI), P1 (95% Commercial Feed + 5% FTKPTI), P2 (90% Commercial Feed + 10% FTKPTI), P3 (85% Commercial Feed + 15% FTKPTI), P4 (80% Commercial Feed + 20% FTKPTI).

Energy retention is the amount of energy consumed by fish that can be stored and utilized in the body [32]. Energy in fish is obtained by the amount of feed consumed, the energy obtained from overhauling chemical bonds through an oxidation reaction process to feed components, namely fat, protein and carbohydrates into simpler compounds (fatty acids, amino acids, and glucose) so the body can absorb that for use or storage [13]. Sukmaningrum et al. [33] stated that energy in feed is physiologically used for maintenance and processing; the residue will be deposited as body tissue in the growth process and for the synthesis of renewed products.

The statistical analysis of commercial feed substitution using fermentation of banana peel flour and fish meal on the energy retention of siam catfish meat did not give a significant difference (p> 0.05) in all treatments. Treatment P0 (Control) has a low value but not significantly different from the treatment P1 (5% FTKPTI), P2 (10% FTKPTI), P3 (15% FTKPTI), and P4 (20% FTKPTI), this can be due to the content Feed energy between treatments which is almost the same, P0 (3112.82 Kcal/kg), P1 (2975.997 Kcal/kg), P2 (2839 Kcal/kg), P3 (2702.352 Kcal/kg), and P4 (2565.53 Kcal/kg). This results in the absorption of feed energy P0, which is not significantly different from P1, P2, P3, and P4. Energy metabolism, the content in P4 is lower than that of P0 so that the fish treated with P4 will eat more feed, so that the intake of other nutrients, such as protein. Fish can use protein as a source of energy as well as for growth. High protein intake leads to more energy retention. According to Afrianto and Liviawaty
[13], energy use in the fish body is informed by the amount of feed consumed so that the feed energy is absorbed by it for use or storage.

4. Conclusion
Commercial feed substitution using fermentation of banana peel flour (Musaceae sp.) and fish meal up to a level of 20% did not affect the level of feed consumption, specific growth rate, feed efficiency, fat retention and energy retention in siam catfish (P. hypophthalmus).

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