The effect of earthworms (*Lumbricus rubellus*) in feed formulation on growth and retention of eel (*Anguilla bicolor*)

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Abstract. Earthworms (*Lumbricus rubellus*) has high protein content. The addition of earthworms in feed formulation not only can increase the appetite of eel but also increase the nutritional content in feed. The purpose of this research was to know the potential of earthworms *L. rubellus* in feed formulation that can give increase on the growth and retention. Research’s method was using Complete Randomized Design (CRD) consisted of five treatments and four replication. Treatments in this research were the different addition of earthworms *L. rubellus* in feed formulation which were 0 %, 25 %, 50 %, 75 % and 100 %. The result showed that there were significantly different on the growth and retention of eel during maintenance for 21 days. the best result was on the 100% of earthworms *L.rubellus* addition.

1. Introduction

Eel (*Anguilla bicolor*) has high economic and export commodity from the fisheries sector [1]. According to Afandi and Suhenda [2] eel needs feed with protein content more than 45%. The commercial feed mostly has protein content only 30-40 %, so to increase the protein content in feed, it can be done by adding high animal protein ingredients, such as trash fish, eggs, and earthworms (*Lumbricusrubellus*) [3].Earthworms contain 64-76 % of easily-digested protein that can be hydrolyzed into amino acids that are useful for the body. Earthworms produce many enzymes and they have fishy smell that attracts its predators [4]. The use of proper attractant can stimulate fish to eat the feed quickly, thus giving additional nutrition, such a protein, and increasing the growth and feed efficiency [5]. Growth is closely related to protein and energy retention. Protein retention is the amount of protein that has been consumed and absorbed or utilized to build or repair the damaged body cells also for daily metabolism [6]. While energy retention is the amount of the saved energy in the form of tissues in the fish body that is divided by the amount of energy in the consumed feed [7]. Thus, this research was aimed to know the potential of
Earthworms (*Lumbricus rubellus*) to be used in feed formulation to increase growth and retention value of eels.

2. Methodology

2.1 Preparation of earthworms (*Lumbricus rubellus*)

Earthworms were obtained from Malang, East Java. It was then mixed with formulated feed (commercial feed and fish meal) as much as 0%, 25%, 50%, 75%, and 100% in the form of paste. Feed was then analyzed for proximate analysis (table 1).

| Feed Ingredients | Dry Ingredients | Crude Protein (%) | Crude Fat (%) | Crude Fiber (%) | Ash (%) | NFE (%) |
|-------------------|----------------|-------------------|---------------|----------------|---------|---------|
| Formulation Feed  | 80,029         | 42,067            | 13,011        | 6,806          | 14,228  | 3,916   |
| Earthworms        | 22,896         | 13,634            | 5,749         | 0,548          | 1,589   | 1,376   |

2.1.1 Experimental design

About 100 Eels that has been used were at fingerling state with average weight 20-25 g each as much as 100 eels that came from Malang, East Java. Eels were selected and then acclimatized for about 30 minutes. After that eels were weighed and measured than divided and placed in the aquarium each aquarium contained five eels. During 21 days eels were feeded with treatments feed that were 0%, 25%, 50%, 75% and 100% of earthworms. Eel’s media constantly were controled and also dark or low light. Every week eels were taken to be weighed and measured for the growth rate, feed effiency and feed conversion ratio.

2.1.2 Fish meat compositions

Crude protein content, crude fat, crude fibre, ash, and nitrogen-free extract of eel’s meat were proximately analyzed based on [8].

2.1.3 Growth Rate (GR)

Measurement of growth rate used the formula from [7]:

\[
GR = \frac{W_t - W_o}{t}
\]

Description:

- **GR** = Growth Rate (g/day)
- **W_t** = Final Weight (g)
- **W_o** = First Weight (g)
- **T** = Time (day)

2.1.4 Feed Conversion Ratio (FCR)

[8] stated that the feed conversion ratio could be calculated by using this formula:

\[
FCR = \frac{F}{W_t + D - W_o}
\]
Description:
FCR = Feed conversion ratio
F = Consumed Feed (g)
Wt = Final Weight (g)
D = Weight of dead fish (g)
W0 = First Weight (g)

2.1.5 Feed Efficiency (FE)
Feed efficiency was done by using the following formula [10]:

\[ EP = \frac{Wt - W_0}{F} \times 100\% \]  

Description:
FE = Feed Efficiency
F = Consumed Feed (g)
Wt = Final Weight (g)
D = Weight of dead fish (g)
W0 = First Weight (g)

2.1.6 Protein Retention (PR)
The measurement of protein retention used:

\[ GR = \frac{(Wt - W_0) \text{g}}{\text{Consumed feed's protein (g)}} \times 100\% \]  

Description:
Wt = Final Weight (g)
W0 = First Weight (g)

2.1.7 Energy Retention (ER)
The measurement of energy retention was as follows:

\[ ER = \frac{(E_t - E_0) \text{kcal}}{\text{Energy total of given feed (kcal)}} \times 100\% \]  

Description:
E_t = Final Body Energy
E_0 = First Body Energy
2.1.8 Statistical Analysis

The experiment was conducted following complete randomized design (CRD) and data collected were analyzed by analysis of variance (ANOVA). If there were significant differences, then it was continued with Duncan’s multiple range test with the level of confidence of 0.05 by using SPSS v.16.

3. Results And Discussion

Growth is the increase of length or weight in certain period. In this research, parameters that were used to measure growth were weight and length. After being treated for 21 d with five different treatments, Eels generally increased their weight and length (table 2). The highest weight increment was from treatment P4. However, it was not significantly different than P3. However, P4 was significantly different from P0, P1, and P2. The difference in growth rate was due to the amount of amino acid in given feed. According to Gusrina [11] stated that growth can be reached if feed contains optimal amino acid, while feed with lack of amino acid balance can decrease fish ability to grow,. balance of amino acids can be obtained by using combination of animal and vegetable proteins. So, if the feed has good nutritional profile, it will increase the growth well [12].

ANOVA analysis showed that there was significant differences among treatments and the best result was from Treatment P4 with 100 % of earthworms, as can be seen in Table 2. the lowest growth was seen in Treatment P1 with 25 % of earthworms. According to Hariyadi et al. [13], earthworms (Lumbricus rubellus) has fishy smells that will stimulate the appetite of fish. Eels are fish that eat on the bottom of the pond and they are active and places with low light density or at night (nocturnal). Smell and touch sensor are used by eels to look for food [14]. One of the criteria of feeding for nocturnal fish is by using feed that has odor stimulation [15]. Carnivore fish has the ability to utilize protein better than carbohydrates and fiber. Therefore, fish can utilize the energy to grow by digesting more protein than carbohydrates and fiber.

Feed conversion ratio (FCR) is a ratio of the amount of feed needed to obtain specific weight [16]. Higher value of feed conversion ratio shows that the feed does not effectively affect the growth of the fish. The best feed conversion ratio was gained from Treatment P4 (2.55) with 100 % of earthworms. Earthworms are easily digested by fish[11]. However, in Treatment P0 with the 100 % of earthworms, the FCR was the lowest (7.35). This was related to the ability of fish in digesting the feed. on the feed in Treatment P0 was not 100 % consumed. Treatment P4 gave the best result of 2.55 that means 2.25 kg of feed was needed to give one kg of weight increase. Feed is not 100 % turned into meat, but some of it is used for energy, metabolism, etc. According to Lesmana [17], feed consumed by fish is used for production of meat, energy metabolism, and energy to move.

Table 2. Growth Rate (GR), Feed Conversion Ratio (FCR) and Feed Efficiency (FE).

| Treatments           | Measured Parameters |            |            |            |
|----------------------|---------------------|------------|------------|------------|
|                      | GR(gs/day)          | FCR        | FE(%)      |
| P0 (0 % of earthworms) | 0.17bc ± 1.03       | 7.35d ± 0.42 | 13.5c ± 0.57 |
| P1 (25 % of earthworms) | 0.12c ± 0.005       | 5.77bc ± 0.46 | 16.7bc ± 1.50 |
| P2 (50 % of earthworms) | 0.17c ± 0.02        | 4.06c ± 0.51 | 24.2c ± 3.59 |
| P3 (75 % of earthworms) | 0.25ab ± 0.09       | 3.48b ± 0.81 | 29.5ab ± 7.50 |
| P4 (100 % of earthworms) | 0.33a ± 0.10        | 2.55a ± 0.88 | 39.0a ± 11.16 |

Description :different alphabet of superscript shows significantly difference (P < 0.05)

Feed efficiency is a comparison value between weight increase with consumed feed [12]. The higher the feed efficiency, the faster the growth is [18]. The highest value of feed efficiency came from
Treatment P4 with 100% of earthworms and it gave efficiency value as much as 39.0%. Feed efficiency can be seen from some factors and one of them is feed conversion ratio [19]. Factors that affects feed efficiency value are types of nutritional source and the nutritional content in the feed [18].

Result from table 3 shows that there were no significantly difference (P>0.05) between P0 P1 P2 P3 and P4 treatments. Undifferent result can be state that each treatment with feed formulation and earthworms (Lumbricus rubellus) gave same effect on the protein retention. This happened because the difference of protein content of the given feed has no difference. Beside, generally protein content in the fish body is always kept to remain stable. This matter is suitable with Buwono (2000) who states that protein retention is an image of the amount of protein that has been given and to be asbrobed or utilized to build or repairs the damaged body cells also for daily metabolism. The lowest energy retention value was on P0 treatment with value of 6.6600 and the highest value was on P4 treatment with value of 23.6900. Increasing of energy retention can be happened because in earthworms (Lumbricus rubellus) there is leucine that one of essential amino acids that can be synthesis by body so it has to be added in feed. In this reseach was using earthworms. By proper feeding and proper dogase will increse the energy retention, because on fish the main energy source is protein.

| Treatments | Measured Parameters | Protein Retention | Energy Retention |
|------------|---------------------|-------------------|------------------|
| P0 (0 % of earthworms) | 8.8150 ± 4.02946 | 6.6600 ± 4.2823 |
| P1(25 % of earthworms) | 14.6775 ± 7.39997 | 7.0575 ± 3.17454 |
| P2(50 % of earthworms) | 11.1925 ± 5.30501 | 17.4700 ± 14.33125 |
| P3(75 % of earthworms) | 21.1000 ± 17.5551 | 23.0025 ± 11.75915 |
| P4(100 % of earthworms) | 27.8075 ± 18.49406 | 23.6900 ± 6.11639 |

Table 3 shows that there were no significant differences (P > 0.05) among treatments, due to the lack of difference in protein content of the given feed. Besides that, protein in the fish body is generally always kept stable. According to Buwono [6] stated that protein retention is the amount of protein given with the absorbed or utilized protein, which is used to build or repair the damaged body cells as well as for daily metabolism. The lowest energy retention value was from Treatment P0 (6.6600) and the highest value was from treatment P4 (23.6900). Increased energy retention was due to the existence of leucine, one of the essential amino acids, in earthworms. proper feeding will increse the energy retention because the main energy sourcefor fish is protein.

4. Conclusion
This study has demonstrated that earthworms (Lumbricus rubellus) can be potentially used in formulation of feed to improve the growth and retention of eels (Anguilla bicolor).

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