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THE EFFECT OF PELLETS AND NATURAL FEED COMBINATION IN THE FORM OF INSECTS ON THE PROTEIN CONTENT OF CATFISH (*Clarias* sp.) IN THE MINAPADI CULTIVATION SYSTEM

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ABSTRACT

This study aims to analyze the effect of the combination of pellets and natural feed on catfish protein levels in the minapadi system. The method used was an experimental design with two feeding treatments, which were treatment A (a combination of pellets and natural feed) and treatment B (pellets only). The natural feed consisted of insects available within the minapadi system, while the pellets used were commercial pellets. The study was conducted for 76 days in the rice field area of Donotirto Village, Kapanewon Kretek, Bantul Regency, Special Region of Yogyakarta. Catfish protein content was tested using the Kjeldahl method. The data obtained was statistically analysed using an independent t-test. The average protein content of catfish in treatment A was 16.17%, whereas that in treatment B was 16.89%. The statistical analysis indicated that the combination of pellets and natural feed had no significant effect on the protein content of catfish. These results are presumably influenced by the limited availability of insects during the study, which limited their contribution as natural feed to significantly enhance the protein content of catfish. Theese finding indicates that the utilization of insects within the minapadi system requires improved management and adjustments in cultivation practices to increase their availability. Further studies are therefore necessary to explore alternative natural feed sources as well as modifications to the minapadi system that could enhance insect availability as an additional nutritional resource for catfish.

Keyword: catfish, protein content, feed combinations, minapadi

Introduction

Catfish (*Clarias* sp.) is one of the leading aquaculture commodities in Indonesia. In fish farming activities, feed is one of the main factors that affect the quality and nutrition of fish (Yunaidi *et al*., 2019). The use of feed can reach 60–70% of the total production cost, making it the largest cost component (Arief et al., 2014). The feed commonly used by farmers is commercial pellets whose raw materials are still largely dependent on fishmeal imports, which makes the price of feed relatively expensive (Anam & Indarto, 2018). This condition makes it difficult for cultivators to reduce production costs and obtain optimal profits.

Feed quality is an important factor in fish farming activities because it directly affects the growth and nutritional content of farmed fish. The mismatch between the nutritional needs of fish and the nutritional content of feed can reduce feed efficiency and have an impact on the growth and nutritional quality of fish (Amen *et al*., 2020). Protein is the main nutritional component that affects the protein retention of the fish's body and has direct implications for its growth (Masitoh & Pinandoyo, 2015). Therefore, feeding with the appropriate protein content is an important factor in improving the quality of cultivated catfish.

The use of natural feed can be one of the alternatives to support the fulfillment of protein in fish feed. Natural feed sources that have the potential to be used in fish farming are insects. Insects are one of the largest groups of animals in the world and account for more than 70% of all animal species (Scaraffia & Miesfeld, 2013). Several studies have proven that insects have a high content of nutrients, especially protein. Research results Tiencheu & Womeni (2017) Various types of insects of various orders have been identified to have a high protein content, ranging from 13-77%. The high protein content makes insects one of the natural feed sources to be used in catfish cultivation.

The use of natural feed is generally carried out in combination with artificial feed, with the aim of reducing dependence on commercial pellets while improving the nutritional quality of fish. Several previous studies have evaluated the use of a combination of natural feed and artificial feed in catfish cultivation, including using a combination of natural feed BSF (Berampu *et al.*, 2022; Fauzi, 2022; Jovantheo *et al.*, 2022), silkworm (Mullah *et al.*, 2020), and earthworms (Trisnawari *et al.*, 2014). However, most of the research was conducted on conventional cultivation systems with natural feed provided in a controlled manner.

In contrast to conventional cultivation systems, integrated cultivation systems such as minapadi provide natural feed directly from the cultivation environment. Minapadi is one of the integrated agricultural concepts that combines rice cultivation and fish farming in an integrated manner (Khoirunisa *et al.* (2024). This cultivation technique combines rice cultivation and fish farming on the same land. In minapadi cultivation, fish play a role as a natural pest control by consuming various types of rice insects, which are also a source of food for the fish. Thus, the minapadi system allows a combination of artificial feed and natural feed to occur, thus potentially reducing the need for artificial feed in fish farming activities.

However, until now there is still limited information about the effect of the use of natural insects in the minapadi cultivation system as a complementary feed for pellets on the protein content of catfish. In fact, the availability of insects in this system has the potential to contribute additional nutrients differently than artificial feeding alone. Based on this description, this study was conducted to examine the effect of the combination of pellet feed and natural feed on the protein content of catfish in the minapadi cultivation system.

Methods

Tools and Materials

The tools used include: fishing nets, plastic containers, buckets, Klaper-X insect light traps, plastic trays, analytical scales, DO meters, pH meters, and smartphones. Meanwhile, the materials used include: STP MIT SP SP 30 floating fish pellets, water and soap.

Working Procedure

Minapadi Land Preparation

The preparation of minapadi land in this study includes the construction of a fish pond in the middle of the rice field area. There are two pond plots and two rice fields designed with the design of pond land and rice fields side by side. The area of each pool is 5 x 10 m2 with a depth of 1.5 m. The area of rice fields A and rice fields B is 6 x 12 m^2.

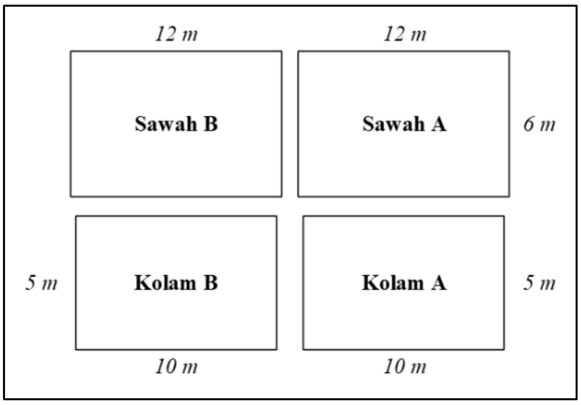


Figure 1. *Minapadi* Layout

Installation of Insect Traps Over Pond A

A Light *Trap is installed on top of pool A, as shown* in Figure 2. There are 6 Light Traps installed, with a distance between them of ±4 meters. Installation *Light Trap* aims to trap insects that are attracted to light at night (Watts, 2018). Insects trapped in the *Light Trap* It is not given as catfish feed because it has been contaminated by soapy water. Therefore, the number of trapped insects does not reflect the exact number of insects given as feed, but only represents the availability of natural feed for catfish in the minapadi cultivation system at the research site. In addition to installing *Light Trap*, in the middle of pond A, an ordinary lamp is also installed to attract insects who are attracted by the light of the lamp, so that the insect falls into the pond and can become a natural feed for fish.

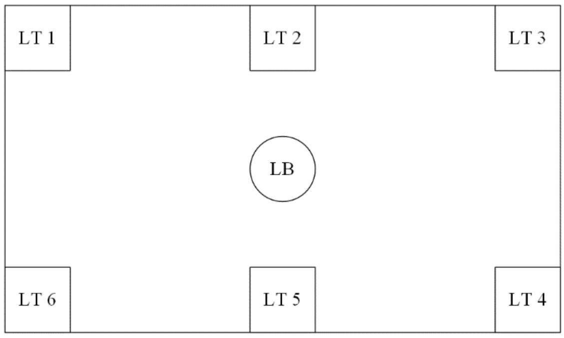


Figure 2. Layout of light trap insect installation in pool A (LT: *light trap*, LB: ordinary light)

Identification of Insects That Become Natural Feed

Insects trapped in the *Light Trap* were identified using *Google Images* and compared to the guidance in the determination keybook Draft *et al.* (2005). The identification data was then grouped by family, order, and genus. After that, the samples were counted to analyze the number of trapped insects, to understand the availability of natural feed in the cultivation environment.

Measurement of the Weight of Insects That Become Natural Feed

Measurement of the weight of insects that are the natural feed of catfish is carried out every observation week. The tools used are *light traps* installed in Pool A to trap insects, as well as analytical scales to measure the weight of the insects. Trapped insects are weighed as a whole without being grouped first, so that the total weight of the trapped insects can be known.

Seed sowing

The distribution of catfish seeds is carried out 44 days after planting rice in the rice field. Catfish seeds in this study were obtained from catfish seeders in the Magelang area. The criteria for selecting seeds include uniform size, as well as being free from diseases and physical defects. A total of 1000 catfish seeds were stocked in each treatment pond (Pond A and Pond B).

Catfish Biomass Measurement

Catfish biomass measurement was carried out once a week, by taking 20 random catfish samples from the total population in each treatment. Catfish samples were weighed by mass using analytical scales, then total biomass calculations were carried out.

Catfish Feeding

Catfish feeding is carried out by two treatments, namely a combination of pellets and natural feed (pond A) and pellets only (pond B). The natural feed on pond A is obtained from insects that are attracted to the light of the lamp above the pond. Meanwhile, the artificial feed used is pellets with the MIT SP 30 brand produced by PT Suri Tani Pemuka. Pellet administration is carried out using the *Relative feeding rate*, which is based on the percentage of fish biomass weight in a pond and adjusted for a certain period of time (Subandiyono & Hastuti, 2021). The amount of feed is 5% of fish biomass (BSN, 2006).

Measurement of Abiotic Factors

Measurements of pool abiotic factors include dissolved oxygen (DO), temperature, and water pH. Pond abiotic factor measurements are carried out once every two weeks for 24 hours with measurement intervals every 2 hours.

Catfish Protein Content Test

The catfish protein content test used 10 samples from each pond. The samples taken have uniform characteristics. The entire sample is cleaned using running water, then all internal organs are removed. Furthermore, the fish meat is separated from the bones by the filleting technique (Primawestri *et al.*, 2023). Catfish protein content testing using the Kjeldahl which was carried out at the Center for Food and Nutrition Studies of Gadjah Mada University. The data on catfish protein content obtained were statistically analyzed using the SPSS T-Independent Data from insect identification, the number of pellets and natural feed, and the water quality of the maintenance pond were analyzed descriptively and based on the literature.

Results and Discussion

Characteristics of Natural Pellets and Feeds Used

Pellet administration is carried out using the Relative feeding rate, which is based on the percentage of fish biomass weight in a pond, measured in any given time period (Subandiyono & Hastuti, 2021). The amount of feed given is calculated as 5% of the fish biomass (SNI, 2006). The results of fish biomass measurements, which can be seen in Figure 3. showed an increase in catfish biomass in each observation week. As the fish biomass increased, the amount of pellets given was also adjusted to the results of the biomass measurements in each observation week (Figure 3.). This adjustment of the number of pellets is made because the nutritional needs of catfish vary, depending on their size and growth stage (Nogales-Mérida *et al.*, 2019).

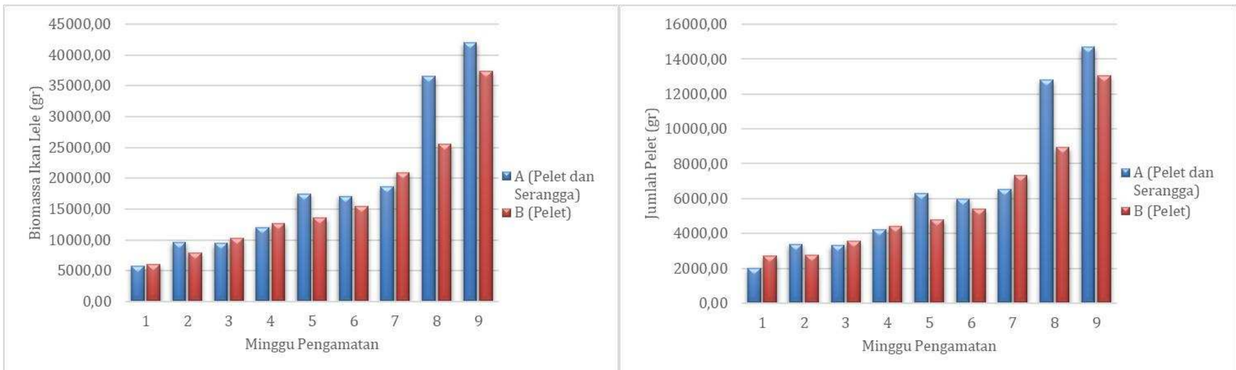


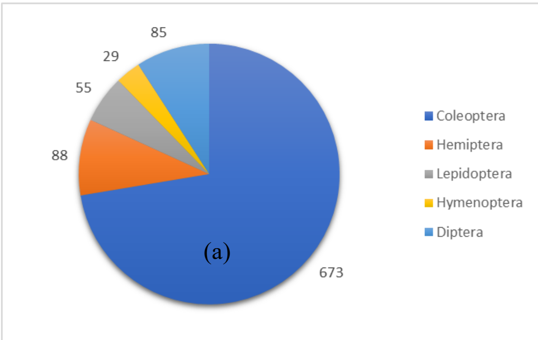
Figure 3. (a) Catfish Biomass; (b) Total Number of Pellets Administered Each Observation Week Remarks

Meanwhile, the natural feed used in this study is insects that are in the minapadi system at the research site. In contrast to pellet feed that is given in a measured manner, natural feeding to catfish is done naturally by utilizing lights installed above the pond to attract insects directly from the rice fields. Therefore, the percentage of natural feed protein content of catfish in this study cannot be known for sure. However, to determine the influence of insects as natural feed, identification of the type and number of insects was carried out every week during the observation period.

Based on the identification results, the most common insects found come from the orders Coleoptera, Hemiptera, Diptera, Lepidoptera, and Hymenoptera. These findings are in line with research conducted by Chatha *et al.* (2024), which states that orders such as Coleoptera, Lepidoptera, Orthoptera, Hemiptera, Hymenoptera, and Isoptera are groups of insects that are often consumed as natural food by fish.

Different types of insects trapped in Light Trap In each observation, the calculation of insect protein content as natural feed for catfish becomes difficult. This is due to the variation in protein content in each type of insect, both at the order and species levels. Xiaoming *et al.* (2010) mentioning that the protein content in insects varies, ranging from 13% to 77%. This variation suggests that different types of insects have non-uniform protein content.

In addition, differences in developmental stages and environmental factors that affect insect habitats also affect insect protein content. Tavares *et al.* (2022) states that the protein content of insects is also influenced by factors such as the life stage of the insect and the condition of its habitat. Thus, the high variability of protein content in each type of insect and environmental factors that affect the availability and composition of insects, make it difficult to estimate the protein content of natural feed in this study.



(b)

Figure 4. Types of Insects Trapped in *Light Traps*

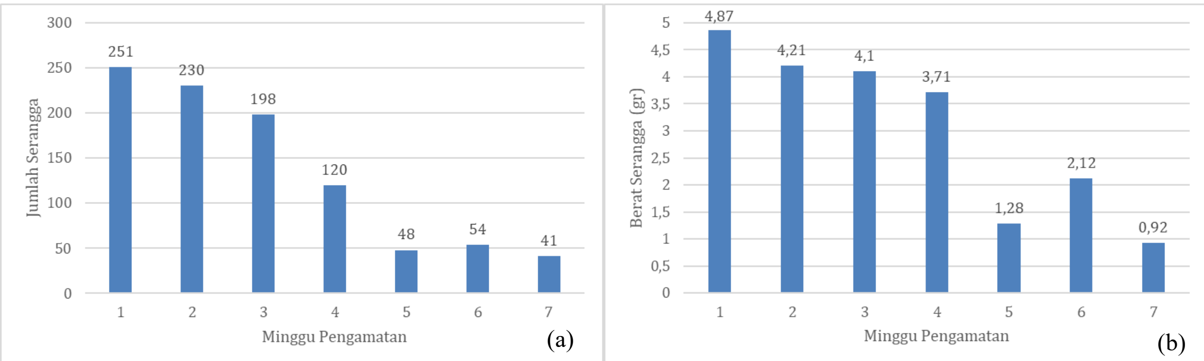


Figure 5. (a) Number and (b) Weight of Insects Trapped in *Light Traps* at Each Observation

In this study, the amount of natural feed of catfish was assumed based on the number of insects trapped in the light trap. Thus, the number of insects trapped in the light trap represents the availability of insects as natural feed for catfish, but does not reflect the exact number of insects that become natural feed for catfish. Based on the results of the calculation of the number of insects (Figure 5.), the number of insects trapped in light traps each week shows fluctuations and tends to decrease over time during observation.

In addition to counting the number of insects, insect weight measurements are also carried out to represent the availability of insects as natural feed for catfish in more measurable quantities. Figure 5 shows the results of the measurement of insect weight in accordance with the results of the calculation of the number of insects that fluctuate and tend to decrease. The weight of insects trapped in light traps every week ranges from 0.92 – 4.87 grams, which is very low when compared to the weight of the pellets given. The results of the calculation of the number of insects and the measurement of the weight of the insects (Figure 5.) indicate that the availability of insects as natural feed is very limited.

Protein Content of Catfish (*Clarias* sp.)

The protein content in catfish samples in this study was analyzed quantitatively using the Kjeldahl. Method Kjeldahl is a simple method to determine the total protein content by counting the element nitrogen (N%) in the sample (Pakerti & Purnama, 2022). Determination of protein content by method Kjeldahl provides results for measuring the crude protein content in a sample, because non-protein nitrogen compounds are also counted. Principle of the method Kjeldahl is the destruction of proteins and organic components in the sample using sulfuric acid and catalysts. The results of the destruction are then neutralized with alkali through the distillation process, and the results are contained in a solution of borate ions. The borate ions formed are then titrated using an HCl solution (Afkar *et al.*, 2020).

In this study, the part of the catfish's body used for testing protein content is the meat part. One of the main components of meat is muscle, which is the main organ where protein accumulates. The protein in the muscle accounts for about 50% of the total protein present in fish (Zhang *et al.*, 2020). Therefore, the meat part is used as the main source for the analysis of the protein content in the body of catfish. The meat of the fish is separated from the rest of the body by the technique Filleting, then analyzed with the Kjeldahl.

Table 1. Catfish Protein Content in Both Feeding Treatments

Sample	Catfish Protein Content (%)	
	A (Pellets + Insects)	B (Pellets)
1	15.34	17.25
2	16.54	15.34
3	16.12	16.39
4	14.27	16.72
5	16.29	17.12
6	16.07	17.31
7	16.80	18.26
8	16.66	16.36
9	16.84	15.53
10	16.75	18.58
Average	16.17 ± 0.81	16.89 ± 1.05

The results of the analysis of the protein content of catfish in both feeding treatments (Table 1.), showed that catfish samples in treatment A (combination of pellets and insects) had an average protein content of 16.17 ± 0.81%, while treatment B (pellets only) was 16.89 ± 1.05%. These results indicate that the protein content of catfish in both treatments is relatively high. In accordance with the statement Stansby (1963), that fish is categorized as low protein if it has a protein content below 15%, high protein if it has a protein content of 15-20%, and very high protein if it has a protein content of more than 20%.

The results of the measurement of protein content in this study are in accordance with those reported in previous studies of the same genus, which range from 13.09% – 16.79% (Naeem *et al.*, 2024) on *Clarias batrachus*, and 13.53% – 15.20% (Fauzi, 2022), 16,03 – 17,74% (Ali & Jauncey, 2005), 14,00 – 14,03% (Ng, 2001) on *Clarias gariepinus.* Cross *et al.* (2012) stated that catfish meat generally contains protein of 12-22%, fat 0.4-5.7%, ash content of 0.8-2%, and water content of 74-85%. Based on these data, the results of the protein content test in this study are still in the normal range.

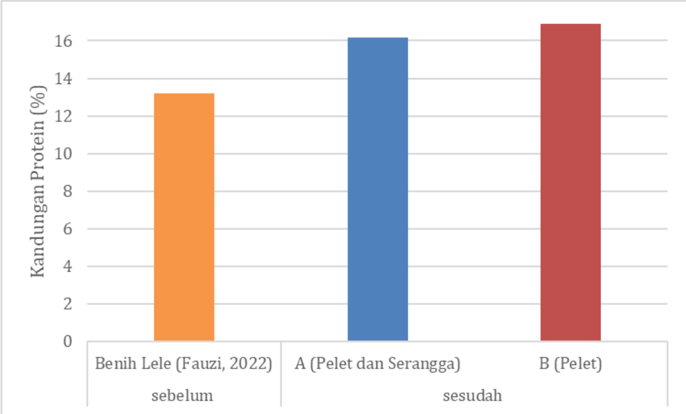


Figure 6. Comparison of Catfish Protein Content Before and After the Maintenance Period

The results of this study also show that the protein content of catfish after maintenance is higher than the protein content of catfish seeds before rearing. Fauzi (2022) reported in his research that catfish seeds (*Clarias sp*.) that are proximate-tested have The protein content is 13.20%. The results of the protein test were obtained through analysis Kjeldahl, just like the one used in this study, thus allowing for a valid comparison between the two research results. Comparison of the protein content of catfish before and after maintenance shown Figure 6.

Based on Figure 6. It can be seen that after the maintenance period, the protein content of catfish in treatment A and B is higher than the protein content of catfish seeds. This is influenced by changes in the body composition of catfish. Shearer (1994) states that the body composition of fish undergoes temporal changes during the process of development, growth, and maturation. After the maintenance period, catfish in treatment A and B experienced an increase in protein content, one of which was caused by changes in body composition, namely an increase in muscle mass. Along with the growth of catfish, there is an accumulation of protein in the body tissues, especially in the muscles. Muscles are the main organs where protein accumulates, and about 50% of the total protein in fish is found in the muscles (Zhang *et al.*, 2020). This leads to an increase in the overall protein content in catfish.

However, the protein test results in both treatments did not match the initial hypothesis. Initially, this study was expected to see a higher increase in protein content in the combination feeding treatment (A) compared to the pellet feeding treatment alone (B). This is because treatment A uses combination feed with the addition of natural feed in the form of insects which is expected to increase the protein content in catfish. In accordance with the statement Toar & Rumokoy (2020) that various types of insects were identified as having a high protein content that could be relied upon as a source of animal feed protein. Thus, treatment A should have a higher protein content due to the addition of natural feed in the form of these insects.

However, the results obtained showed an anomaly, with the average protein content in treatment A using a combination of pellets and natural feed being lower compared to treatment B using only pellets. Based on Table 1. The average protein content in treatment A was 0.72% lower than treatment B. This is thought to be due to the huge variation in protein content in each sample. As can be seen in Table 1, the results of the protein content test between samples in each treatment show considerable differences. This variation can be influenced by competition between catfish in obtaining food to meet their nutritional needs.

Feed competition occurs because the nutrients from the feed provided cannot optimally meet the nutritional needs of catfish. In this study, catfish were raised from seed to juvenile phase. In this phase, catfish require more nutrients than adult fish, because they are still in the process of growth and development that requires optimal nutrient intake to support their survival and growth (Mufidah *et al.*, 2009). The high nutritional needs in this phase cause competition between fish to get feed.

According to Haryasakti & Wahyudi (2024) If the feed is insufficient for the needs of the fish, it can cause competition between fish in getting feed. As a result, not all catfish get enough feed to meet their nutritional needs. This causes a large variation in the protein content of catfish. Thus, although the average protein content in treatment A was lower than in treatment B, the large variation in each treatment resulted in an indeterminacy of which treatment was better.

Table 2. Statistical Test Results of Average Difference in Protein Content between the Two Treatments

Treatment	Protein Content (%)	Sig. (T Test)
A (Pellets + Insects)	16.17 ± 0.81	0.104
B (Pellets)	16.89 ± 1.05	

Based on the results of the statistical test, the average difference between treatment A and B (Table 2.), showed that there was no significant difference ($p>0.05$) between the average protein content of catfish fed a combination of pellets and natural feed (A) and those fed only pellet feed (B). This indicates that the combination of pellet feed and natural feed in the form of insects does not have a significant effect on increasing the protein content of catfish.

The main factor that causes the combination treatment of pellets and natural feed to have no significant effect on the protein content of catfish is the limited number of insects available in the minapadi cultivation system in this study. This assumption was obtained from the results of measurements of the weight of the insects at each observation (Figure 5.), which showed very small amounts ranging from 0.92 to 4.87 grams. Therefore, insects as natural feed cannot make a significant contribution to increasing the protein content of catfish, because their number is limited so that they are not optimal enough for catfish nutritional needs.

The insufficient availability of insects to meet the nutritional needs of catfish can affect the eating behavior patterns of the fish. Brutov (1979) stated that the predation behavior of catfish is influenced by the availability of prey, which includes prey density and its level of accessibility. In line with the research, Tesfahun (2018) states that catfish's eating habits depend on the accessibility of resources in the environment, which determines catfish's eating preferences and preferences. In this study, the results of measuring the weight of insects trapped in Light Trap (Figure 5.) shows very small numbers, which indicates that the insects that fall into the water and become catfish feed are also very limited. This condition causes the level of predation of catfish to insects to be low, and insects are not the main source of feed chosen by catfish.

The results that have no real effect can also be influenced by the physiological factors of the fish which have a homeostasis mechanism that keeps the protein content in the body stable. This mechanism of homeostasis regulates the balance between protein synthesis and oxidation of free amino acids in the fish's body tissues Houlihan *et al.* (1995). According to Buttle *et al.,* (1995), when the amino acids absorbed from food exceed the fish's body's needs for growth and maintenance, those amino acids cannot be stored and will degrade resulting in nitrogen waste products, most of which are ammonia.

Water Quality

Water quality has a significant influence on the quality of life of the fish, because water not only functions as a medium for swimming, but also plays an important role in supporting various activities and biochemical reactions that occur in the fish's body (Kurniawan, 2012). Water quality measurements are carried out once every two weeks, with observed parameters including temperature, dissolved oxygen (DO), and pH. The results of water quality measurement (Table 3.) show that the value of water quality parameters in treatment A and B does not show significant differences and is still within the limits set by SNI (2006). Each of the water quality parameters, such as pH, temperature, and dissolved oxygen content, interacts with each other and affects each other. This condition is important because optimal water quality can affect fish metabolism, thus having an impact on the growth and composition of the fish's body, including its protein content.

Table 3. Pond Water Quality During Research

Parameters	Treatment		Threshold (SNI, 2006)
	A (Pellets+Insects)	B (Insect)	
Temperature	28,9 – 30,1	29.1 – 30.2°C	25 – 30
DO (mg/L)	6,73 – 10,95	6,73 – 11,23	>4
pH	7,5 – 8,4	6,5 – 8,5	6,5 – 8,5

Temperature is the water quality parameter that has the most influence on all other parameters and catfish cultivation results. As a poikilothermal organism, the body temperature of fish depends on the temperature around it, so that body temperature can fluctuate according to the temperature of its environment (Kamler, 1989). As a result, temperature changes can affect enzymatic reactions, cellular respiration, and oxygen consumption, all of which contribute to changes in the metabolic rate of fish (Volkoff & Rønnestad, 2020). Dissolved oxygen in a body of water is obtained through diffusion from air into water or through the photosynthesis of aquatic plants (Ali *et al*., 2022). Meanwhile, dissolved oxygen in water can be reduced due to respiration and organic decay in the waters (Mubarak *et al*., 2010). The pH value describes the acidity or alkalinity of the water, which affects the ion balance and acid-base regulation in the fish's body. Fish have mechanisms to maintain this balance, but changes in pH in the environment can disrupt that mechanism, leading to acid-base imbalances that impact the metabolism, respiration, and overall health of the fish (Marium *et al*., 2023). At an acidic pH below 4 and a base pH of more than 11, which is a pH that causes metabolic disorders to death in fish (Yonarta *et al*., 2023).

Conclusion

The combination of pellets and natural feed did not have a significant effect on the protein content of catfish. This result is suspected to be influenced by the limited availability of insects as natural feed in the minapadi system, so that its contribution as a source of additional nutrients is not enough to significantly increase the protein content of catfish. These findings show that the success of the use of natural feed in the minapadi system depends not only on the type of feed, but also on the level of its availability in the cultivation environment.

Practically, the results of this study indicate that the application of the minapadi system is not reliable as an additional natural feed source without management efforts aimed at increasing the availability of insects in cultivated land. Therefore, farmers still need to rely on artificial feed as the main source of protein for catfish. Further research is suggested to explore alternative types of natural feed that are more abundant or easier to develop in the minapadi system, as well as to make adjustments to the design of the cultivation system, such as vegetation management, rice planting time, or modification of microhabitats, in order to increase the availability of insects as natural feed for catfish.

References

Afkar, M., Nisah, K., & Sa'diah, H. (2020). Analysis of protein levels in corn flour, cassava flour and yellow pumpkin flour using the Kjedhal method. *AMEN*, *1*(3), 108–113. https://doi.org/10.22373/amina.v1i3.46

Ali, B., . A., & Mishra, A. (2022). Effects of dissolved oxygen concentration on freshwater fish: A review. *International Journal of Fisheries and Aquatic Studies*, *10*(4), 113–127. https://doi.org/10.22271/fish.2022.v10.i4b.2693

Ali, & Jauncey, K. (2005). Effect of dietary protein to energy ratio on body composition, digestive enzymes and blood plasma components in Clarias gariepinus. *Indian Journal of Fisheries*, *7* (October 2014), 141–150.

Amin, M., Taqwa, F. H., Yulisman, Y., Mukti, R. C., Rarassari, M. A., & Antika, R. M. (2020). The effectiveness of the use of local raw materials as fish feed to increase the productivity of Catfish (Clarias sp.) cultivation in Sakatiga Village, Indralaya District, Ogan Ilir Regency, South Sumatra. *Journal of Aquaculture and Fish Health*, *9*(3), 222. https://doi.org/10.20473/jafh.v9i3.17969

Anam, C., & Indarto, C. (2018). The production of rucah fish meal to increase the income of fishermen in Paciran Lamongan. *AXIOLOGY: Journal of Community Service*, *2*(2), 160. https://doi.org/10.30651/aks.v2i2.1241

Arief, M., Fitriani, N., & Subekti, S. (2014). The present effect of different probiotics on commercial feed towards growth and feed efficiency of Sangkuriang Catfish (Clarias sp.). *Scientific Journal of Fisheries and Marine*, *6*(1), 5.

National Standards Agency (NSA). (2006). *Artificial feed for Dumbo Catfish (Clarias gariepinus) in intensive cultivation* (SNI 01-4087-2006).

Berampu, L. E., Patriono, E., & Amalia, R. (2022). A combination of maggot and commercial feed was given for the effectiveness of additional feeding of Sangkuriang Catfish (Clarias gariepinus) fish seeds by catfish farming groups. *Sriwijaya Bioscientia*, *2*(2), 1–15. https://doi.org/10.24233/sribios.2.2.2021.315

Borror, D. J., Triplehorn, C. A., & Johnson, N. F. (2005). *Borror and Delong's introduction to the study of insects*. Brooks/Cole.

Bruton, M. N. (1979). The food and feeding behaviour of Clarias gariepinus (Pisces: Clariidae) in Lake Sibaya, South Africa, with emphasis on its role as a predator of cichlids. *The Transactions of the Zoological Society of London*, *35*(1), 47–114. https://doi.org/10.1111/j.1096-3642.1979.tb00057.x

Buttle, L. G., Uglow, R. F., & Cowx, I. G. (1995). Effect of dietary protein on the nitrogen excretion and growth of the African catfish, Clarias gariepinus. *Aquatic Living Resources*, *8*(4), 407–414. https://doi.org/10.1051/alr:1995048

Chatha, A. M. M., Naz, S., & Danabas, D. (2024). Effect of insect feed on fish growth: a review. *Asian Fisheries Science*, *37*(1), 52–68. https://doi.org/10.33997/j.afs.2024.37.1.004

Cruz, N., Cruz, P., & Suárez, H. (2012). Characterization of the nutritional quality of the meat in some species of catfish: A Review. *Revista Facultad Nacional de Agronomía Medellín*, *65*(2), 6799–6709.

Deniro, Sadarun, & Yusnaini. (2017). Effect of increasing sea water treatment on the behavior of Staghorn Sergeant (Amblyglyphidodon Curacao) Iin control containers. *Sapa Laut*, *2*(3), 61–67.

Fauzi, S. H. (2022). *Growth and nutritional content of Catfish (Clarias sp.) meat fed with Maggot (Larva Hermetia Illucens) and commercial feed*. Gadjah Mada University.

Haryasakti, A., & Wahyudi, M. H. (2024). The effect of feeding frequency on the growth rate and survival rate of Sangkuriang Catfish (Clarias gariepinus) in tarpaulin ponds. *Journal of Integrated Agriculture*, *11*(2), 149–160. https://doi.org/10.36084/jpt..v11i2.511

Houlihan, D. F., McCarthy, I. D., Carter, C. G., & Marttin Houlihan, F. (1995). Protein turnover and amino acid flux in fish larvae. *ICES Mar. S. Symp*, *201*, 87–99.

Jovantheo, I., Hapsari, U., Prasetyatama, Y. D., & Sutiarso, L. (2022). The effect of feed variations on the Mutiara Catfish (Clarias gariepinus) growth performance in the integration farming technology system. *Proceedings of the 2nd International Conference on Smart and Innovative Agriculture (ICoSIA 2021), 191*–196. https://doi.org/10.2991/absr.k.220305.028

Khoirunisa, A. B., Herawati, N., & Kusumawati, A. (2024). The application of an integrated farming system in rice fields through rice mines as a solution to overcome agricultural issues. *Journal of Top Agriculture*, *2*(2), 93–101. https://doi.org/10.56854/jta.v2i2.190

GB. (2024). *Data on the production volume of aquaculture aquaculture for the enlargement of catfish commodities per province (Ton).* https://statistik.kkp.go.id/home.php?m=prod_ikan_prov&i=2#panel-footer-kpda

Marium, A., Chatha, A. M. M., Naz, S., Khan, M. F., Safdar, W., & Ashraf, I. (2023). Effect of temperature, pH, salinity and dissolved oxygen on fishes. *Journal of Zoology and Systematics*, *1*(2), 1–12. https://doi.org/10.56946/jzs.v1i2.198

Marlina, E., Aghitsnillah, N. Q., Aruhi, N., Rosyid, N. M., Maharani, L. E., Mudakir, F., Sri Wilujeng, E. W., Ekariani, A., Ocvando, K., Hidayat, F., Pawestri, N. A., & Al Farrosi, F. U. (2020). Catfish cultivation as a form of food self-sufficiency for the village community. *Journal of Community Empowerment Learning (JP2M), 1*(2), 110. https://doi.org/10.33474/jp2m.v1i2.6468

Masitoh, D., & Pinandoyo, S. (2015). The effect of different feed protein content with an E/P value of 8.5 kcal/g on the growth of Goldfish (Cypinus carpio). *Journal of Aquaculture Management and Technology*, *4*(3), 46–53.

Mubarak, A., Satyari, & Kusdarwati, R. (2010). Correlation between dissolved oxygen concentrations at different densities with the color scoring of Daphnia spp. *Scientific Journal of Fisheries and Marine*, *2*(1), 45–50.

Mudjiman, A. (2004). *Revised edition of fish food*. Self-Sustaining Spreader.

Mufidah, N., Rahardja, B., & Satyantini, W. (2009). Enrichment of Daphnia spp. with viterna on the survival and growth of Dumbo Catfish larvae (Clarias gariepinus). *Scientific Journal of Fisheries and Marine* Science, *1*(1), 59–65.

Mullah, A., Diniarti, N., & Astriana, B. H. (2020). The effect of the addition of Silkworm (Tubifex) as a combination of artificial feed on the efficiency of feed utilization and the larval growth of Sangkuriang Catfish (Clarias gariepinus). *Unram Fisheries Journal*, *9*(2), 160–171. https://doi.org/10.29303/jp.v9i2.163

Naeem, Z., Zuberi, A., Ali, M., Naeem, A. D., & Naeem, M. (2024). An approach to optimizing dietary protein to growth and body composition in walking catfish, Clarias batrachus (Linneaeus, 1758). *PLoS ONE, 19*(5 May), 1–15. https://doi.org/10.1371/journal.pone.0301712

Ng, W. K. (2001). Potential of mealworm (Tenebrio molifor) as an alternative protein source in practical diets for African catfish, Clarias gariepinus. *Aquaculture Research*, *32*(SUPPL. 1), 273–280.

Nogales-Mérida, S., Gobbi, P., Józefiak, D., Mazurkiewicz, J., Dudek, K., Rawski, M., Kierończyk, B., & Józefiak, A. (2019). Insect meals in fish nutrition. *Reviews in Aquaculture*, *11*(4), 1080–1103. https://doi.org/10.1111/raq.12281

Pakerti, A. L., & Purnama, R. C. (2022). Analysis of protein levels in corn (Zea mays L.) purchased with brand L in the market region of Semuli Jaya North Lampung with using The Kjeldahl Method. *Journal of Pharmaceutical Analysts*, *7*(2), 119–129.

Primawestri, M., Sumardianto, & Kurniasih, R. A. (2023). Characteristics of Catfish (Clarias gariepinus) sticks with a comparison of meat and bone ratios. *Journal of Fisheries Science and Technology*, *5*(1), 1–23.

Scaraffia, P. Y., & Miesfeld, R. L. (2013). Insect Biochemistry/Hormones. In *Encyclopedia of Biological Chemistry: Second Edition* (2nd ed.). Elsevier Inc. https://doi.org/10.1016/B978-0-12-378630-2.00093-1

Shearer, K. D. (1994). Factors affecting the proximate composition of cultured fishes with emphasis on salmonids. *Aquaculture*, *119*(1), 63–88. https://doi.org/10.1016/0044-8486(94)90444-8

Stansby, M. E. (1963). *Industrial fishery technology*. Reinhold Publishing Corporation.

Subandiyono, & Hastuti, S. (2021). *Application of parent feed management in catfish hatchery (Clarias gariepinus)* (Vol. 1). CV. Tigamedia Pratama. www.tigamedia.id

Tavares, P. P. L. G., dos Santos Lima, M., Pessôa, L. C., de Andrade Bulos, R. B., de Oliveira, T. T. B., da Silva Cruz, L. F., de Jesus Assis, D., da Boa Morte, E. S., Di Mambro Ribeiro, C. V., & de Souza, C. O. (2022). Innovation in alternative food sources: a review of a technological state-of-the-art of insects in food products. *Foods*, *11*(23). https://doi.org/10.3390/foods11233792

Tesfahun, A. (2018). Feeding biology of the African catfish Clarias gariepinus (Burchell) in some of Ethiopian Lakes: a review. *International Journal of Fauna and Biological Studies*, *5*(1), 19–23. https://www.researchgate.net/publication/322675358

Tiencheu, B., & Womeni, H. M. (2017). Entomophagy: Insects as Food. *Insect Physiology and Ecology*, *April*. https://doi.org/10.5772/67384

Toar, W. L., & Rumokoy, L. J. M. (2020). An alternative source of protein from insects for poultry feed. *National Seminar in the Framework of the 44th Anniversary of UNS in 2020 "Food Security Strategies for the New Normal Covid-19," 4*(1), 491–496.

Trisnawari, Y., Suminto, & Sudaryono, A. (2014). The effect of the combination of artificial feed and earthworm (Lumbricus rubellus) on the efficiency of feed utilization, growth and survival of

Dumbo Catfish (Clarias gariepinus). *Journal of Aquaculture Management and Technology*, *3*(4), 9–17.

Volkoff, H., & Rønnestad, I. (2020). Effects of temperature on feeding and digestive processes in fish. *Temperature*, *7*(4), 307–320. https://doi.org/10.1080/23328940.2020.1765950

Watts, C. (2018). Identification of rice plant pests (Oriza sativa L.) with light traps in Desay Village, Prafi District, West Papua Province. *Journal of Agricultural Extension*, *9*(2), 77–86.

Xiaoming, C., Ying, F., Hong, Z., & Zhiyong, C. (2010). Review of the nutritive value of edible insects. *Forest Insects as Food: Humans Bite Back*, *85*.

Yonarta, D., Susanto, T., & Rarassari, M. A. (2023). The effect of natural feeding is different on the growth of Catfish Larvae (Clarias sp.). *Aquatic Pen : Scientific Journal of Fisheries and Marine* Science, *22*(2), 21. https://doi.org/10.31941/penaakuatika.v22i2.3478

Yunaidi, Y., Rahmanta, A. P., & Wibowo, A. (2019). Application of artificial pellet feed to increase the productivity of freshwater fish cultivation in Jerukagung Srumbung Magelang village. *Journal of Empowerment: Publication of Community Service Results*, *3*(1), 45–54. https://doi.org/10.12928/jp.v3i1.621

Zhang, Y., Lu, R., Qin, C., & Nie, G. (2020). Precision nutritional regulation and aquaculture. *Aquaculture Reports*, *18*, 100496. https://doi.org/10.1016/j.aqrep.2020.100496