Feeding an artificial rush fish for the growth and survival of mud grouper (*Epinephelus lanceolatus*)

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Abstract. Mesjid Lama Village is one of the villages with fishing potential in the Batu Bara Regency. This village is also one of the locations where mud grouper (*Epinephelus lanceolatus*) ponds are cultivated. Farmers used to provide fresh trash fish that has been cut into pieces proportional to the grouper's mouth size. The trash fish has a three-day shelf life; after 3 days, it decomposes, preventing the grouper from consuming it. As a result, trash fish is processed into pellets for use as artificial feed. The method used in this study is an experimental method involving 60 days of artificial feeding. The treatment given consisted of 5 types, namely a mixture of trash fish flour and soybean flour with ratio of 0%:100%; 25%:75%; 50%:50%; 75%:25%; and 100%:0% respectively. The information gathered was used to determine the effect of treatment on the parameters evaluated using the completely randomized design (CRD) model. The results show that feeding artificial trash fish pellets containing 100% trash fish flour and 0% soybean flour resulted in the highest growth rate (3.3%) and feed efficiency (30.63%) compared to other treatments. The highest grouper survival rate during 60 days of rearing was approximately 89%, indicating that 100% trash fish flour can effectively support grouper survival.
Key Words: artificial feeding, *Epinephelus lanceolatus*, mud grouper, survival rate.

Introduction. Grouper is a carnivorous fish and one of the fishery products with high economic value, opportunities on both domestic and international markets, and a relatively high selling price of approximately Rp75,000/kg (5 USD/kg) (Allal et al 2022). Farmers cultivate various grouper species, including mud grouper, beautiful grouper, tiger grouper, batik grouper, sunu grouper, duck grouper, and others. Among these species, mud grouper (*Epinephelus lanceolatus*) is one of the most popular species (Langkosono 2007; Triana 2010; Sutina et al 2017).

In Indonesia, grouper is still cultivated using explosives or poisons (potassium cyanide) that contribute to extinction and damage the environment. The Ministry of Marine Affairs and Fisheries of the Republic of Indonesia recognizes grouper as one of the country's superior commodities (Subyakto 2017). Therefore, development is required to maximize production by maintaining healthy ponds, providing high-quality feed, and controlling pests and diseases (Sim et al 2005; Sudrajat et al 2011). It is difficult for farmers to increase production due to fish slow growth. Slow grouper growth will necessitate more food, resulting in high production costs. Poor seed quality, unfavorable environmental conditions, and insufficient feeding are among the factors slowing grouper growth (Nugroho 2010; Rhodes et al 2016). Farmers typically provide groupers with natural food in the form of trash fish. Trash fish is sold for a relatively low price (Fatimah 2015). The selling price of trash fish in the market is Rp2,500-Rp4,000/kg (0.16-0.26 USD/kg) (Hidayatullah et al 2015) The availability of trash fish, however, varies by season. Therefore, fish should be fed artificial food, so they do not rely on trash fish as natural food (Azra & Ikhwanuddin 2016).

Grouper cultivators in Mesjid Lama Village, Batu Bara Regency, use fresh trash fish as grouper feed. Trash fish is abundant in Batu Bara Regency, but fresh trash fish does not last long. When the trash fish is not fresh, groupers do not eat it, so it spoils and is wasted (Sim et al 2005). This is a problem faced by farmers, and research must be conducted on the pelletization of fresh trash fish into feed for mud grouper. However, mud grouper is obtained from nature, so the food given to them is also natural. Therefore, in addition to making feed with the main ingredients of trash fish, this study also carried out special treatment so that groupers eat artificial feed.

Material and Method

Description of the study sites. The study was conducted in Mesjid Lama Village (Figure 1), Talawi (Jalan Mangga II), Batu Bara Regency, North Sumatra, from February to March 2022. The manufacture of trash fish pellets was carried out at the Aquaculture Laboratory, Universitas Asahan. Furthermore, the proximate test (chemical analysis to identify nutrient in feed ingredients) was conducted at Universitas Riau.

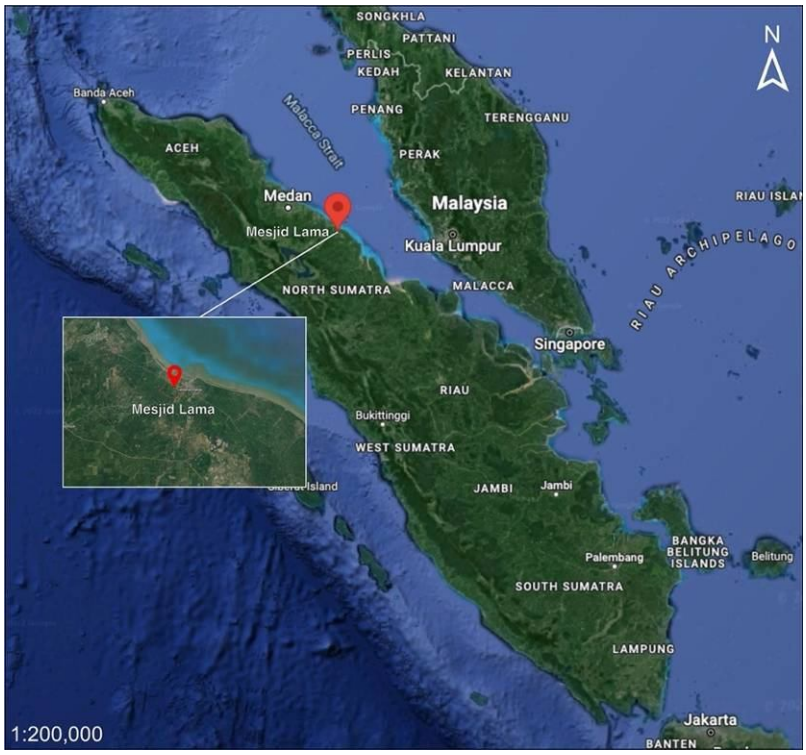

Figure 1. The location of Mesjid Lama, Batu Bara Regency.

Research execution

Materials and tools preparation. The tools used in this research were analytical balance (Ohaus Adventurer), filter, net, basin, spoon, pellet grinder, mortar, winnowing, thermometer, pH meter (HANNA HI9125), DO meter (Dixson Tech, DO9100), stationery, and camera (Sony A6000). The materials used in this study were test fish in the form of mud grouper fry with an average size of 4.21 cm with an average weight of 1 g each, as many as 225 fish for 15 containers. Meanwhile, trash fish were consisted of ogak fish, goatfish, cucut fish (milk shark), bloated fish, ray fish, and tamban fish (silver-stripe round herring). The trash fish was collected in a 16 L container as many as 15 containers.

Research method. The method used in this study is experimental to determine the variables in a group under controlled conditions (Sugiyono 2011). The experimental design used was a completely randomized design (CRD) (Hanafiah 2005). The treatments given are as follows (n = 3):

A = 0% trash fish flour, 100% soy flour;
B = 25% trash fish meal, 75% soy flour;
C = 50% trash fish flour, 50% soy flour;
D = 75% trash fish meal, 25% soy flour;
E = 100% trash fish flour, 0% soy flour.

Research procedure

Making of fish trash flour. The initial process of making a trash fish meal was with fresh trash fish washed clean, then steamed for 25 minutes; after that, it was drained, and the cold fish was mashed with a mortar. The fish that have been refined were dried in the sun, then the dried fish were sifted into more refined flour (Assadad et al 2015).

Making of pellet. Before making pellets, feed formulation was done to determine the ingredient composition with a protein requirement of 45% and ratio variations of A, B, C, D, and E as presented in the previous section. The ingredients used were weighed as needed. The process of mixing was carried out gradually, starting from the lowest to the highest portion of ingredients until the mixture was homogeneous. The method for producing pellets involved mixing trash fish flour, soybean flour, fine bran, wheat flour, vitamin mix, and mineral mix until the ingredients were thoroughly mixed, followed by the addition of water while stirring evenly so that lumps can be formed. Each composition of the ingredients was different for each variation (A, B, C, D, and E). Therefore, the composition was determined based on calculation in the following section. After the mixing process, the material was molded by grinding pellets suiting to the mouth size of the grouper fish, followed by drying under the sunlight.

Feed formulation. The amount of feed to be produced was ±10 kg for each treatment. To determine the composition of each treatment's ingredients, it is necessary to consider the percentage of final protein content. In this study, each treatment contained 45% of protein, which was supplied from supplements (protein > 20%) and basals (protein < 20%). The protein content of each treatment is summarized in Table 1, while the composition's determination can be seen in the following calculation results.

Table 1

Protein content of each ingredient

Material	*Protein content*
Trash fish flour	37.70%
Soy flour	32.45%
Fine bran	12.35%
Wheat flour	10.50%

Each treatment contains six ingredients: trash fish flour, soybean flour, fine bran, wheat flour, vitamin mix and mineral mix. Vitamin and mineral were determined as 2% (200 g) of the total composition, respectively. Since every treatment generated 10 kg pellet product, so the remaining ingredients needed is 9.6 kg, obtained from 10 kg - (200 g + 200 g).

Protein requirement = 45%;

Protein requirement after the addition of vitamin and mineral mix =

$$\frac{\text{protein requirement}}{\text{remaining ingredients}} \times 100 = \frac{45}{100 - 4} \times 100 = \frac{45}{96} \times 100 = 46.88\%$$

As a result of the addition of the vitamin and mineral mix (4% of the total weight), the protein requirement used to determine the composition of other ingredients is 46.88%. The Pearson Square was then used to determine the ingredient composition based on the protein requirement. Pearson Square is a method for determining the

portion of two feeds needed to meet protein or energy requirements of an animal (Gusrina 2008).

Table 1 presents data about protein content of each ingredient which was obtained from laboratory analysis. The materials with protein content more than 20% were classified as supplementary protein, which are trash fish and soybean flour. Meanwhile, with protein content below 20%, fine bran and wheat flour were classified as basal protein.

$$\text{Supplementary protein} = \frac{\%\text{trash fish flour} + \%\text{soy flour}}{2} = \frac{37.70\% + 32.45\%}{2} = \frac{70.15\%}{2} = 35.075\%$$

$$\text{Basal protein} = \frac{\%\text{fine bran} + \%\text{wheat flour}}{2} = \frac{12.35\% + 10.50\%}{2} = \frac{22.85\%}{2} = 11.425\%$$

Using those supplementary and basal protein data, the following calculation based on Pearson Square can be used to determine the composition of fish feed ration for protein requirement of 46.88%. In a Pearson Square, the composition of a component is calculated depending on the composition of other components; therefore, in this calculation, the supplementary is calculated by considering %basal, and vice versa.

Supplementary = %protein requirement - %basal protein = 46.88% - 11.425% = 35.455%

Basal = %protein requirement - %supplementary protein = 46.88% - 35.075% = 11.805%

Total = supplementary + basal = 35.455% + 11.805% = 47.260%

Furthermore, the mass of each ingredient can be calculated as follows:

$$\text{Mass of supplementary} = \frac{\%\text{supplementary}}{\%\text{total}} \times \text{mass of remaining ingredients} = \frac{35.455\%}{47.269\%} \times 9.6\text{ kg} = 7.2\text{ kg}$$

$$\text{Mass of basal} = \frac{\%\text{supplementary}}{\%\text{total}} \times \text{mass of remaining ingredients} = \frac{11.805\%}{47.269\%} \times 9.6\text{ kg} = 2.4\text{ kg}$$

The allocation of the 7.2 kg of supplementary protein for trash fish flour and soy flour is determined by their ratios in treatments A, B, C, D, and E. Meanwhile, the 2.4 kg of basal protein is split in half for fine bran and wheat flour, with each 1.2 kg. Table 2 provides details on the composition of each ingredient in all treatments.

Table 2

Composition of each ingredient in each treatment

Treatment	*Ingredients*					
	Trash fish flour	*Soy flour*	*Fine bran*	*Wheat flour*	*Vitamin mix (2%)*	*Mineral mix (2%)*
A	0 kg (0%)	7.2 kg (100%)	1.2 kg	1.2 kg	200 g	200 g
B	1.8 kg (25%)	5.4 kg (75%)	1.2 kg	1.2 kg	200 g	200 g
C	3.6 kg (50%)	3.6 kg (50%)	1.2 kg	1.2 kg	200 g	200 g
D	5.4 kg (75%)	1.8 kg (25%)	1.2 kg	1.2 kg	200 g	200 g
E	7.2 kg (100%)	0 kg (0%)	1.2 kg	1.2 kg	200 g	200 g

Feeding and observing the fish. This study used fry of the mud grouper with a total of 225 fish, which were divided into 5 treatments so that each treatment had 45 fish. Each treatment had 3 containers (n = 3) so that each container contained 15 fish. To calculate the initial weight and length of a fish, it was first weighed and then its total length was measured. Before the test fish were used in the treatment, the fish were adapted for two weeks. The procedure for adapting fish included fasting it for 3 days. After that, the fish were fed using prawns mixed with artificial feed (pellets). Finally, the fish were fed using petrogenol attractant to stimulate the fish appetite for the prepared feed.

Fish rearing was carried out in a 16 L-transparent jar filled with 10 L of salted water with a total of 15 jars (5 treatments x 3). The treatment containers were aerated. The water medium in the jar had a salinity of 28-30 ppt. Fish were fed at satiation with the frequency of feeding three times a day, namely at 08.00, 13.00, and 17.00. The total length and weight of the fish were measured at the beginning (first 20 days), middle (second 20 days), and end (third 20 days) of the study, from February to April 2022. Length and weight, daily growth rate, feed efficiency, and survival rate were the measured parameters. In addition, temperature, pH, dissolved oxygen, and salinity were used to measure water quality. Throughout the 60-day study, measurements were obtained once every week. Water was replaced every three days or when it became muddy. The condition of water quality during the study is shown in Table 3.

Table 3

Water quality

Treatment	*Temperature (^oC)*	*pH*	*DO (mg L^{-1})*	*Salinity (ppt)*
A	30-31	2.84	5.20-10.50	28-30
B	30-31	2.84	5.20-10.50	28-30
C	30-31	2.84	5.20-10.50	28-30
D	30-31	2.84	5.20-10.50	28-30
E	30-31	2.84	5.20-10.50	28-30

Test parameters

Fish weight and length. Weight (g) and length (cm) measurements were carried out based on formulas developed by Effendie (2002):

Absolute weight gain = Wt-Wo (1)
Absolute length gain = Lt-Lo (2)

where: Wt is the fish final weight, Wo is the fish initial weight, Lt is the fish final length and Lo is the fish initial length.

Daily growth rate. According to Huisman (1976), the growth rate can be measured using the following formula:

$$\alpha = \left(t\sqrt{\frac{\overline{Wt}}{\overline{Wo}}} - 1 \right) \quad \text{x } 100 \quad (3)$$

where: α is weight growth rate (%), t is the length of the study (weeks), $\overline{Wt}$ is the average weight of fish at the end of the study (g), and $\overline{Wo}$ is the average weight of fish at the beginning of the study (g).

Feed efficiency. The amount of feed given throughout the study and the weight of the fish at the beginning and end of the study will provide information regarding feed efficiency. Watanabe (1988) proposed the following formula for determining feed efficiency:

$$FE = \frac{(Bt + Bd) - Bo}{F} \times 100 \quad (4)$$

where: FE is feed efficiency (%), Bt is fish weight at the end of the study (g), Bd is weight of dead fish during the study (g), Bo is fish weight at the beginning of the study (g), and F is the amount of feed consumed by fish during the study.

Survival rate. The number of live fish at the beginning and end of the study provides information regarding the survival rate of fish. According to Effendie (2002), the survival rate can be calculated using the following formula:

$$SR = \frac{Nt}{No} \times 100 \quad (5)$$

where: SR is survival rate (%), Nt is the total of live fish at the end of the study, and No is the total of live fish at the beginning of the study.

In addition, proximate analyses, including fat, crude fiber, protein, water, ash, and carbohydrates, were performed on trash fish flour and the produced pellets (Tables 4 and 5).

Table 4

Results of the proximate analysis of trash fish flour

Test parameter	*Results (%)*
Fat	10.58
Crude fiber	4.68
Protein	32.46
Water	18.43
Ash	32.82
Carbohydrate	0.47
Total	99.44

Table 5

Results of the proximate analysis of fish feed pellets from each treatment

Test parameter	*Treatment*				
	A (%)	*B (%)*	*C (%)*	*D (%)*	*E (%)*
Fat	15.60	9.08	6.71	6.16	6.80
Crude fiber	8.55	4.82	6.36	6.81	5.65
Protein	33.02	37.87	30.15	34.69	31.59
Water	7.92	8.89	8.94	10.43	9.95
Ash	6.71	10.11	14.27	18.31	24.16
Carbohydrate	11.28	9.08	12.38	15.86	5.35
Total	83.08	79.85	78.81	92.26	83.50

Data analysis. The study's data were presented in tabular format, and the growth rate, feed efficiency, and survival rate were calculated according to the provided formulae. Analysis of variance (ANOVA) was conducted to examine the effect of treatment on the tested parameters. Before performing the analysis, the collected data must be normally distributed and homogeneous. If the probability value (p) is less than 0.05, then the administration of pellets affects grouper growth. The Newman-Keuls test was conducted to determine the difference between each treatment.

Results. During 60 days of feeding and observation, the highest absolute length growth was observed in treatment E (100% trash fish flour) with a value of 1.065 cm, while the lowest absolute length growth was observed in treatment A (100% soybean flour) (Figure 2). In addition, the highest absolute weight of grouper was observed in treatment E with a value of 1.997 grams, while the lowest was observed in treatment A (Figure 3). The highest daily growth rate of grouper was found in treatment E with a value of 3.33%, while the lowest was found in treatment A with a value of 0.57% (Figure 4). Meanwhile, the treatment with the highest feed efficiency was E, with a value of 30.63% and the treatment with the lowest feed efficiency was A, with a value of 5.32% (Figure 5). In addition, the highest survival rate was E with a value of 89%, while the lowest survival rate was found in treatment A with a value of 42% (Figure 6).

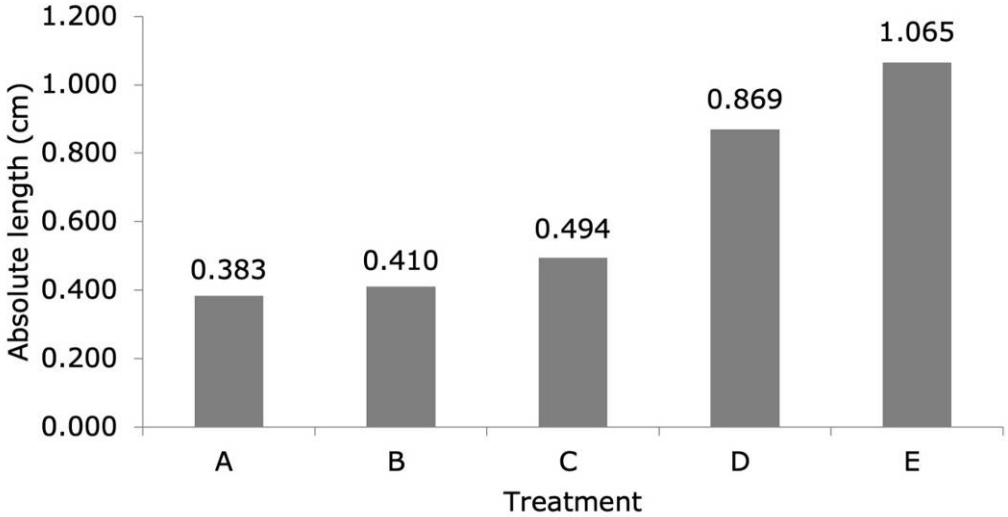

Figure 2. Absolute length growth of mud grouper.

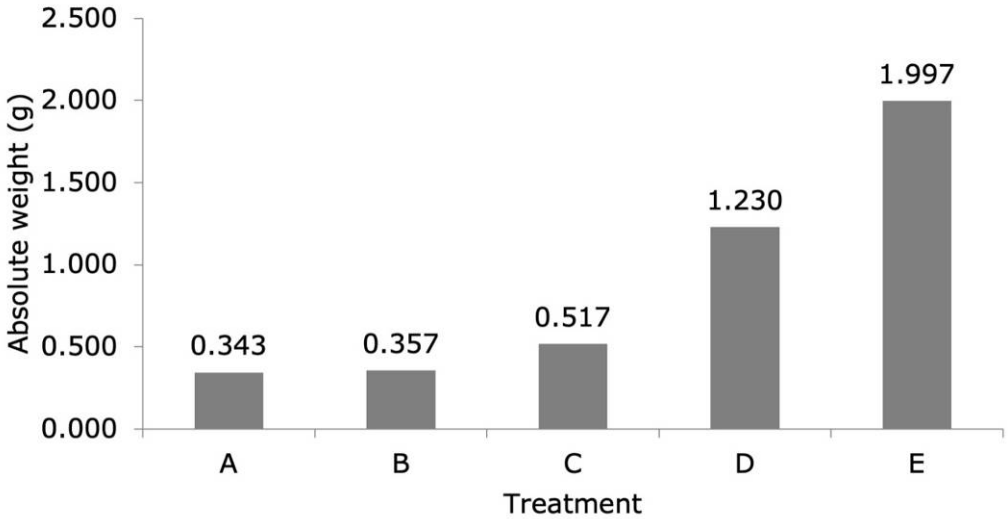

Figure 3. Absolute weight growth of mud grouper.

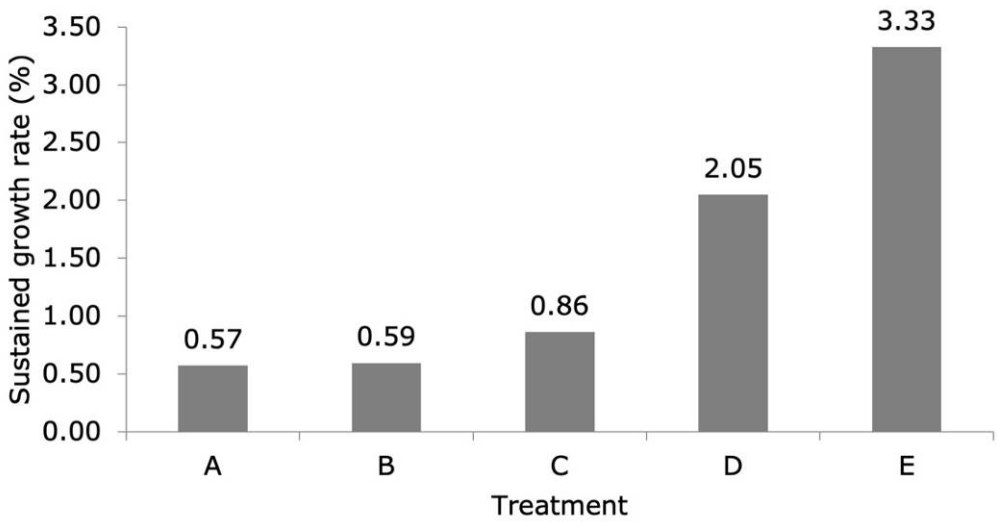

Figure 4. Mud grouper daily growth rate.

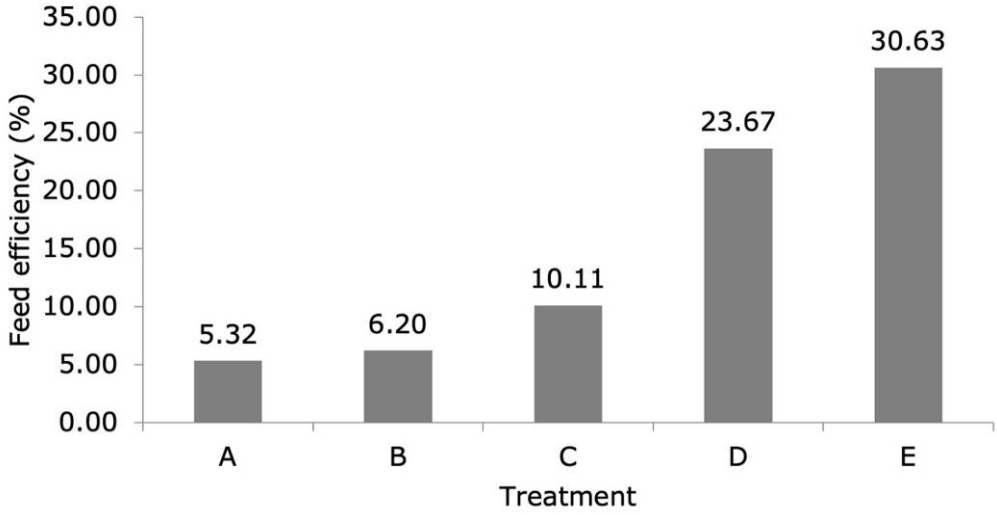

Figure 5. Mud grouper feed efficiency.

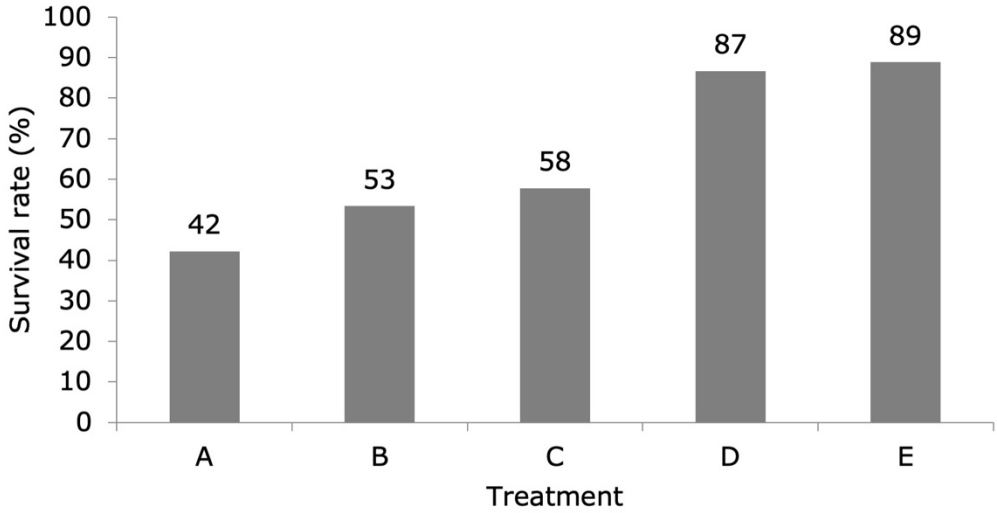

Figure 6. Mud grouper survival rate.

Discussion. During the study, the average growth rate of grouper ranged from 0.57 to 3.33% (Figure 4). The highest average rate is found in treatment E at 3.33%, and the lowest is found in treatment A at 0.57%. According to Agustin et al (2022), feeding snakehead fish (*Channa striata*) using 15% trash fish meal and 15% shrimp resulted in a growth rate of 11.07%. Meanwhile, Utomo et al (2015) found that using trash fish feed as a protein led to a growth rate of 5.56%. In addition, Yolanda et al (2013) explained in their study that using 100% trash fish feed for Nile tilapia fish (*Oreochromis niloticus*) resulted in a growth of 15.83 g. The result of the current study (3.33%) is lower than other studies mentioned. This is because mud grouper comes from the sea and is accustomed to eating natural food such as small fish (Selfati et al 2018), crustaceans, and plankton, as well as the lack of ingredients in artificial feed in the form of animal protein which makes the grouper disinterested in eating pellets. The average feed efficiency during the study ranged from 5.32 to 30.63% (Figure 5). Treatment E produced the highest feed efficiency with a value of 30.63%, while treatment A had the lowest with a value of 5.32%. This is because 100% trash fish flour is more appealing to groupers than other feeds. The ingredients have a distinct flavor and aroma to stimulate the fish's appetite (Yin et al 2021). Besides, it is also one of the animal proteins contents because the grouper prefers the content of feed ingredients that contain animal protein over other ingredients (Nankervis et al 2022). Meanwhile, Utomo et al (2015) used trash fish meal as catfish (*Clarias* sp.) feed, which resulted in a high feed efficiency of 63.15%. Pinandoyo et al (2021) used trash fish meal and fermented chicken manure in Sangkuriang catfish (*Clarias* sp.) feed, which produced the highest feed efficiency in treatment of 70% trash fish meal and 30% fermented chicken manure. In addition, Akbar & Soemarno (2012) found that using pellets and trash fish in tiger grouper (*Ephinephelus fuscoguttatus*) feed resulted in the highest feed efficiency ranging from 29 to 40%.

The highest survival rates were obtained during the study ranging from 42 to 89% (Figure 6). The high survival rate of fish indicates that the use of trash fish meal in artificial feeds is acceptable for groupers. Among the biotic factors that influence survival rate are competitors, population density, age, and the capacity of organisms to adapt to their environment (Nankervis et al 2022). Mortality determines the success of maintenance efforts in agriculture. High mortality can occur if the seeds do not receive the proper type and quantity of food immediately (Armiah 2010). Several factors also contribute to the high mortality rate, including cannibalism. The presence of cannibalism can be determined from the dead fish, whose bodies have been damaged by cannibalism (Duk et al 2017). Mortality is caused not only by the nature of cannibalism but also by the stress caused by environmental changes in fish (Schreck & Tort 2016). When sudden environmental changes occur at a specific time, the fish immune system will weaken and cause death (Solihin et al 2015). Finally, the mortality rate occurs when fish are not stimulated to consume artificial feed due to ingredients that do not meet their nutritional requirements.

Water quality factors include temperature, pH, DO, and salinity (Retnani & Abdulgani 2013). Water is an essential living medium for fish existence. Based on water quality measurement data collected during the maintenance period, it is known that the temperature range for each treatment is between 30 and 31°C (Table 3). The temperature range in grouper that is good for growth is 25-32°C (Sim et al 2005). According to Langkosono (2007) research, cantang grouper (Serranidae) can grow at temperatures between 25 and 32°C. According to the data, the temperature content is suitable for grouper survival.

The measurement results for pH during the study were in the range of 2.84, while the DO measurement ranged from 5.20 to 10.50 mg L^{-1}, and salinity measurements ranged from 28 to 30 ppt. According to Decree No. 51 (2004) of the State Minister of the Environment regarding standard quality of seawater, the dissolved oxygen content of > 5 mg L^{-1} is optimal for the development of biota. The analysis on water quality parameters revealed that the water quality during the study was still quite good and did not vary between treatment containers.

Conclusions. Based on the research conducted, it can be concluded that trash fish meal can be used to stimulate the growth of mud grouper fry when added to the artificial feed. Good treatment in artificial feeding on mud grouper fry is with a percentage of 100% trash fish flour which produces a growth rate of 3.3% and a feed efficiency of 30.63% (the highest compared to other treatments). In addition, the highest grouper survival rate during 60 days of rearing was approximately 89%, indicating that 100% trash fish flour can effectively support grouper survival.

Conflict of interest. The authors declare that there is no conflict of interest.

References

Agustin A., Emilda E., Sari T. A., 2022 [Growth response of snakehead fish (*Channa striata*) when feeding with artificial feed of trash fish and shrimp meal]. EduBiologia: Biological Science and Education Journal 2(1):55-62. [in Indonesian]

Akbar S., Marsoedi, Soemarno, Kusnendar E., 2012 [The survival rate of tiger grouper (*Epinephelus fuscoguttatus*) at nursery phase given polyvalent vaccines]. Jurnal Teknologi Pangan 3(1):76-85. [in Indonesian]

Allal A., Boudjemaa K., Dehimi S., 2022 The effect of spatial differences on the quality of urban life: a comparative analytical study of three cities in the high plateaux region of Algeria. GeoJournal of Tourism and Geosites 40(1):181-190.

Armiah J., 2010 [Utilization of tofu dregs fermentation in feed on the growth of lais fish fry (*Ompok hypophthalmus*)]. BSc thesis, Faculty of Fisheries and Marine Science, Universitas Riau, Pekanbaru, Indonesia, 98 pp. [in Indonesian]

Assadad L., Hakim A. R., Widianto T. N., 2015 [Quality of trash fish meal in various processing method]. In: Seminar Nasional Tahunan XII Hasil Penelitian Perikanan dan Kelautan 2:52-63. [in Indonesian]

Azra M. N., Ikhwanuddin M., 2016 A review of maturation diets for mud crab genus *Scylla* broodstock: present research, problems and future perspective. Saudi Journal of Biological Sciences 23(2):257-267.

Duk K., Pajdak J., Terech-Majewska E., Szarek J., 2017 Intracohort cannibalism and methods for its mitigation in cultured freshwater fish. Reviews in Fish Biology and Fisheries 27(1):193-208.

Effendie M. I., 2002 [Fisheries biology]. Yayasan Pustaka Nusatama, 163 pp. [in Indonesian]

Fatimah E. N., Sari M., 2015 [Tips for successful cultivation of catfish]. Bibir Publisher, 82 pp. [in Indonesian]

Gusrina, 2008 [Fish farming. Volume 2]. Ministry of Education of the Republic of Indonesia, 178 pp. [in Indonesian]

Hanafiah K. A., 2005 [Experimental design]. PT. Raja Grafindo Persada, 103 pp. [in Indonesian]

Hidayatullah S., Muslim M., Taqwa F. H., 2015 [Rearing of snakehead larvae (*Channa striata*) in plastic line pond with different stocking density]. Jurnal Perikanan dan Kelautan 20(1):61-70. [in Indonesian]

Huisman E. A., 1976 Food conversion efficiencies at maintenance and production levels for carp, *Cyprinus carpio* L., and rainbow trout, *Salmo gairdneri* Richardson. Aquaculture 9:259-273.

Langkosono L., 2007 [Grouper (Serranidae) cultivation and water quality]. Neptunus 14(1):61-67. [in Indonesian]

Nankervis L., Cobcroft J. M., Nguyen N. V., Rimmer M. A., 2022 Advances in practical feed formulation and adoption for hybrid grouper (*Epinephelus fuscoguttatus* ♀ × *E. lanceolatus* ♂) aquaculture. Reviews in Aquaculture 14(1):288-307.

Nugroho E., 2010 [Making aquaculture as an independent business incubator: valuable lessons from Taiwan]. Media Akuakultur 5(1):62-66. [in Indonesian]

Pinandoyo, Syakirin M. B., Mardiana T. Y., 2021 [Utilization of trash fish and fermented chicken manure in catfish feed on growth and survival rate of Sangkuriang catfish (*Clarias* sp.)]. PENA Akuatika 20(1):1-16. [in Indonesian]

Retnani H. T., Abdulgani N., 2013 [Effect of salinity on protein content and growth of pomfret (*Trachinotus blochii*)]. Jurnal Sains dan Seni Pomits 2(2):177-181. [in Indonesian]
Rhodes K. L., Taylor B. M., Hernandez-Ortiz D., Cuetos-Bueno J., 2016 Growth and reproduction of the highfin grouper *Epinephelus maculatus*. Journal of Fish Biology 88(5):1856-1869.
Schreck C. B., Tort L., 2016 The concept of stress in fish. Fish Physiology 35:1-34.
Selfati M., El Ouamari N., Lenfant P., Fontcuberta A., Lecaillon G., Mesfioui A., Boissery P., Bazairi H., 2018 Promoting restoration of fish communities using artificial habitats in coastal marinas. Biological Conservation 219:89-95.
Sim S. Y., Rimmer M. A., Williams K., Toledo J. D., Sugama K., Rumengan I., Phillips M. J., 2005 A practical guide to feeds and feed management for cultured groupers. NACA, Bangkok, Thailand, 18 pp.
Solihin S., Muhtarudin M., Sutrisna R., 2015 [The effect of a long storage on water content physical qualities and fungus scatters wafers of vegetables and potatoes waste]. Jurnal Ilmiah Peternakan Terpadu 3(2):48-54. [in Indonesian]
Subyakto S., Cahyaningsih S., 2017 [Grouper hatchery for household scale]. PT. Agromedia Pustaka, 37 pp. [in Indonesian]
Sudrajat A., Wedjatmiko, Setiadharma T., 2011 [Milkfish cultivation technology]. Maritime and Fisheries Research and Development Agency, Ministry of Maritime Affairs and Fisheries, 89 pp. [in Indonesian]
Sugiyono, 2011 [Quantitative, qualitative, and R & D research methods]. Alfabeta, 252 pp. [in Indonesian]
Sutina, Yunus R., Seniwati, 2017 Market structure of grouper fish in Indonesia. Science International 29(2):219-222.
Triana S., 2010 [Analysis of DNA fragment obtained from groupers (*Epinephelus fuscoguttatus*) challenged by *Vibrio alginolyticus*]. Jurnal Ilmu Dasar 11(1):8-16. [in Indonesian]
Utomo N. B. P., Susan, Setiawati M., 2013 [Role of various fishmeal ingredients on Sangkuriang catfish *Clarias* sp. growth]. Jurnal Akuakultur Indonesia 12(2):158-168. [in Indonesian]
Watanabe T., 1988 Fish nutrition and mariculture. Department of Aquatic Bio-science, Tokyo University of Fisheries, Tokyo, 233 pp.
Yin B., Liu H., Tan B., Dong X., Chi S., Yang Q., Zhang S., 2021 MHC II-PI_3K/Akt/mTOR signaling pathway regulates intestinal immune response induced by soy glycinin in hybrid grouper: protective effects of sodium butyrate. Frontiers in Immunology 11: 615980.
Yolanda S., Santoso L., Harpeni E., 2013 [Effect of fish meal substitution with trash fish meal on the growth of Nile tilapia (*Oreochromis niloticus*)]. Jurnal Rekayasa dan Teknologi Budidaya Perairan 1(2):95-100. [in Indonesian]
*** Ministry of Environment of the Republic of Indonesia, 2004 Decree of the Minister of Environment No. 51 of 2004 concerning Seawater Quality Standard. [in Indonesian].

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