Feeding habits of giant trevally *Caranx ignobilis* (Carangidae) rearing in floating cage nets

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Abstract. The aim of this research is to determine the amount of trash fish the fish need for growth, and possible saving strategies through reducing the amount of feed until the minimum requirement is reached. Bubara fish *C. ignobilis* was reared in aquatec floating cages, each cage measuring 3m x 3m x 3m. In this study, the fish were reared in four smaller bags, with the size 1.5m x 1.5m x 1.5m placed in one large bag. As many as 75 fish with varying sizes were placed in a small bag, while 20 selected fish were allowed to measure. Fish that are placed in small bags vary in size with a length of 9.56 - 11.125 cm (TL) and a weight of 6.5 - 8.7 g. Each small bag was given different treatments, successively as follows: three day fasting - three day eating (T3), four day fasting - four day eating (T4), and five day fasting - five day eating (T5). Fish are fed 10 -15% of the total biomass, at 8:00 a.m. and 5:00 p.m. daily for 70 consecutive days. Every week, the measurement of waters parameters is carried out to determine the condition of the waters that support aquaculture activities. The results showed that there was weight gained in the three treatments which were stated based on the absolute growth rate in weight (AGR): 0.65 g.day⁻¹ in T3 treatment; 0.77 g.day⁻¹ in T4 treatment; and 0.80 g.day⁻¹ in T5 treatment. Bubara fish *C. ignobilis* also had the best survival rates during the rearing period even though they were treated without food with the survival rates of 90 - 95%. The efficiency of feed utilization as stated by the FCR shows that the treatment without food (fasting treatment) can be used as a mode to reduce feed spending. Treatment without food is also able to increase the number of small intestinal villi to expand the absorption surface, so that more feed is used compared to those left to rot at the bottom of the bag.

1. Introduction

*Caranx ignobilis* (Forsskål, 1775), the popular name Giant Trevally (GT) belongs to the order Perciformes, family Carangidae, genus Caranx [1]. In Maluku, this species is one of the so-called bubara fish (local name). Bubara fish is a common name not only for *C. ignobilis* but also for a number of species from the same Carangidae family, such as *C. sexfasciatus* and *C. melanpygus*. The bubara fish *C. ignobilis* is the largest in Caranx genus, measuring up to 170 cm and weighing 87 kg [2]. This species is a top predator in its habitat, because it has a habit of hunting prey individually and in groups, with the main prey is smaller fish, crustaceans and cephalopods [3]. Because of its highly agile and resilient hunting habits make this species a target for hunting by many professional fish anglers [4]. On the other hand, *C. ignobilis* is an economically important marine fish favored by most community, due to its dense meat texture and delicious taste. Bubara fish can be obtained in almost all traditional markets in Maluku. Although easy to obtain, this species is traded at a fairly high price, depending on its availability in the market. The price of bubara fish in various locations also varies widely. The price this fish in the city of Ambon [5] and Manado [6] is IDR 75,000 / kg, even from time to time it can reach IDR 100,000 / kg or more. Other species of genus Caranx
can be obtained at a lower price, possibly as part of the catch by nets and fishing rods, as well as the cultivated product of floating cages. The cultivation of bubara fish in Maluku waters has also been going on for a long time, especially in the Ambon bay, at least since two decades ago. Cultivation of marine cage in Ambon bay is used to take place in the inner part of the bay, then switched to the outer part, because it was considered safer after the density of inner Ambon bay as the port for many ships, and after the presence of the “Merah-Putih” Bridge which connected some villages of Galala-Hative Kecil and Rumah Tiga-Poka villages. The cultivated fish species is also vary from grouper (Epinephelus sp and Cromileptes sp), to “samandar” fish (Siganus sp) and bubara fish (Caranx sp). Cultivation with Aquatec-floating cages or common which is generally supported by natural fish seed sources from coastal areas along the inner Ambon bay, even recently it has grown with the supply of seeds from Fishery and Marine Cultivation Center in Waiheru, Ambon. It is possible to cultivate C. ignobilis at this time, due to the availability of seeds from Waiheru center. Furthermore, the cultivation of C. ignobilis is very necessary, because the growth rate of this species is recorded to be higher than that of other bubara fish [7], which so far have been cultivated at first. The successful of Caranx aquaculture depends on the feed which is the favorite of these fish and is capable of accelerating growth, namely trash fish which is often somewhat difficult to obtain, thus more often affecting the price at the consumer level. In general trash fish still has a relatively high market price, but from time to time it has a very low price, so it can be used as fish feed, such as feeds from Decapterus and Sardinella. The cultivation of bubara fish i.e., C. melampygus and C. ignobilis continues to grow, both in Indonesia [8] and other countries [9]. The number of studies on phenotypic and physiological adaptation strategies is still very small when compared to research on biological and physiological aspects of bubara fish that live in free waters [10,11]. In addition, there are several notes on the cultivation of bubara fish in floating net cages. Although they are still anecdotal, these notes are very important as early input that helped this research. In fact that the aspect of feed regulation does not appear to be a problem for several types of cultivated fishermen, both freshwater and marine fish alike in a number of locations mentioned. This does not mean that the ability to overcome feeding aspect can easily be practiced in other species without going through appropriate researches. This is because there are still some obstacles regarding to the ability to sufficient procurement, nutritious and cheap feed to support such cultivation. These things matter a lot, especially in the current conditions when people from all over the world face the corona virus pandemic. There are many alternative of feeding options including the frequency and amount of feed given to achieve optimum growth must be sought immediately. The purpose of this study was to determine the eating habits of fish that led to grow and reared in floating cage with the main feed is trash fish, and the possibility of fish to do fasting, by analyzing the proportion of different feeds, analyzing the effect of the cultivation area as well as testing the effect of prolonged intermittent feeding on growth and physiological aspects of bubara fish C. ignobilis.

2. Materials and Methods

2.1. Field work
The research on the growth of Caranx ignobilis has been carried out at the Aquatec-floating cage of cultivation facility - belonging to the Department of Aquaculture - Faculty of Fisheries and Marine Sciences of Pattimura University - Ambon. The rearing period of bubara fish lasts for 6 months, namely from August to December 2020, where all activities taking place in Ambon bay water (Figure 1).
2.2. Fish for examination
The seeds of *C. ignobilis* used in this research are available by local fishermen in Ambon bay. The seedlings received is relatively less stressful due to fishing gear used, and is quite healthy with a survival rate of more than 90%. Seeds from nature are always not uniform in size, so every seed obtained must be subjected to a grading process. This is the process of separating seeds based on size in order to obtain a relatively similar size which is then placed in the same rearing bag, and allowed to fast for four days before treatment.

2.3. Research design
Fish used in this study was *C. ignobilis* with sizes of 9.56-11.125 cm (TL) and weights of 6.5-8.7 g. After being transferred from the fishermen facility, fries were acclimatized to the experimental conditions directly in Aquatec floating bags for four days. This research uses four small floating bags with a size of 1.5m x 1.5m x 1.5m each. Each bag can accommodate as many as 75 individual fish to receive treatment, and one control. The first treatment was T3, underwent three days fasting and three days feeding. The same treatment pattern was also carried out for the second (T4) and the third (T5) treatment. Each treatment applies one replication for every cage. Fish are given one type of trash feed as much as 10-15% of the total biomass. The fish is fed manually two times, namely at 08.00 and 17.00 until they appear to reach a satiated stage. A total period of time for all experiments last for 70 days. While the measurement of water qualities such as salinity, pH, and temperature was done weekly until the end of the experiments.

2.4. Statistical calculation
The calculation was carried out regarding to the effect of fasting process on:

a. Performance and changes in morphometric characters was calculated with Brury Coefficient [12]

b. Growth performance was calculated with analysis of length (L) and weight (W) relationships and comparison between species

c. Factors of condition and level of fitness (robustness) and comparison among species

d. The feed and growth performance were analyzed through for 70 days:
   - Specific growth rate (SGR) (% h⁻¹) was calculated with the formula:
     \[ SGR = \frac{100 \times (\ln \text{final body weight} - \ln \text{initial body weight})}{h} \]
   - The feed conversion (FCR) was calculated with the formula:
FCR = \sum \text{Feed given (g) / Weight obtained} \ [14].

- Feed intake (Feed Intake, \% fish\(^{-1}\) h\(^{-1}\)) was calculated with the formula:

\[ FI = 100 \times \sum \text{forage consumed (g)} \left[\left(Wo - Wt\right) / t\right] \ [15], \]

where: \(Wo\) is the initial weight of fish,
\(Wt\) is the final weight of fish,
\(t\) is the length of treatment time.

- Compensation Coefficient (CC) was calculated with the formula:

\[ CC = \Delta T / \Delta C, \]

where: \(\Delta T\) is the mean weight intake (g) in the treatment group / number of days eaten.
\(\Delta C\) is the average weight intake (g) in the control group / number of days eaten.

As a standard, there has been a growth compensation, we can use the condition of hyperphagia or when there is a high spike in craving for food, which causes growth which also spikes unusually. As a reference standard, the value of \(CC > 1\) that indicates positive compensation [16, 17].

- Survival rate analysis (SR, \%), was analyzed with a formula:

\[ SR = \text{Number of live fish} / \text{Number of days eaten} \]

- The calculation of the hepatosomatic index will be carried out based on the formula:

\[ HSI = WL / W \ [18], \]

where: \(W_L\) is the liver weight
\(W\) is the fish weight.

Liver proximate analysis has been done for several components which include: (a) crude lipid, (b) crude protein, (c) moisture, (d) ash, and (e) plasticity of the digestive system; which includes the size of the intestine, the mass of the stomach and intestines. To determine the effect of grasping on the plasticity of the digestive system of the fish, the analysis uses one factor ANOVA. To test the sensitivity of the factors applied to the test fish, the main hypothesis are:
- \(Ho: u1 = u2\), There is no satisfying effect on the length of intestine
- \(Ho: u1 = u2\), There is no satisfying effect on the weight of intestine

d. Intestinal histomorphology, through the histological process, the real changes in the intestinal tissue morphology such as a number of villi can be calculated.

e. Compensatory Growth Analysis (CG) of fish, several parameters has been analyzed include: survival rate (SR), initial weight (Wo), final weight (Wt), total day (t) and absolute growth rate (AGR), where AGR is calculated with the formula:

\[ AGR = [(Wt - Wo) / t] \ [19]. \]

While, the average level of fish consumption in each experimental was calculated based on a total number of feed given to fish / a number of days fed.
2.5. Statistical analysis
The entire statistical analysis used in this study is the One-Factor Variance Analysis (ANOVA). The honest real difference test, Duncan test [20] was used to analyze the differences in each variable amongst three existing treatments. Covariance analysis (ANCOVA) is also used to test the regression coefficients of the analyzed independent and dependent variables.

3. Result and Discussion

3.1. Homogeneity test
The homogeneity test of the weight variation (Wt) which was carried out on the fish that received the fasting treatment showed that the smallest fish length variation was 3.67 g and the largest one was 11.17 g. The results of calculations using the F max method show a value of 3.09. When compared with the value at F 0.05 (2), 4.19, the value is 3.29, which is greater than the calculation of F max.

The same calculation was done for the fish that received the cage size treatment and its effect on the culture where the smallest variant was 2.18 cm and the largest was 3.05 cm. The results of the F max test give a value of 1.39 which is smaller than F table 3.51. The results of the analysis of the variety on the size of the fish in the feed efficiency treatment cage on growth gave the smallest size variety of 2.185 and the largest was 2.230. The results of the calculation of F max give a result of 1.020. Overall, the results of the above calculations lead us to accept the previous hypothesis that there is no significant difference in the variance of fish size in each experimental unit. This proves that each individual fish which placed into experimental units is done randomly. This step is really needed as a prerequisite to fulfil the experimental design.

3.2. Growth, condition factors, and feed conversion ratio
The growth performance of *C. ignobilis* observed during this period (70 days) can be seen in Table 1. At the time this research was started, the initial average weight was 6.5 - 8.7 g and the average weight at the end obtained between 53.22 - 102.55 g.

| Table 1. Mean ± SE of baseline weight, survival rate, final weight and absolute growth rate |
| Group | n  | Initial weight (g) | SR (%) | Final weight (g) | Absolute growth rate (g/day) |
|--------|-----|---------------------|--------|------------------|-------------------------------|
| T3     | 20  | 7.85 ± 1.89         | 90     | 53.22 ± 8.96     | 0.65                          |
| T4     | 20  | 6.50 ± 2.93         | 90     | 60.06 ± 13.15    | 0.77                          |
| T5     | 20  | 8.70 ± 3.34         | 95     | 64.89 ± 18.04    | 0.80                          |
| Control| 20  | 7.15 ± 2.64         | 100    | 102.00 ± 18.68   | 1.36                          |

The results of the analysis suggest that bubara fish *C. ignobilis* has a very good survival rate during its rearing period (Table 1). Even in conditions of limited feed intake, the survival rate remains high (90 - 95%) of the three treatments. The achievement of final weight and absolute growth in the fish group fasting for 5 days and feeding for 5 days showed better results (0.80) compared to the other two treatments. The smallest absolute growth value was obtained in the fish group with treatment T5 which was 0.65. The results of other studies [21, 22], showed that the daily growth rate of *C. melampygus* was 1.57-1.72%.

To find out whether there is a compensation response to the treatment given, then the CC is analyzed. This analysis was simultaneously used to detect the ability of fish to restore growth momentum lost due to the depression period of fasting [23]. The results of the analysis provide a CC value of 1.61 where this value
is greater than 1.0, which gives a positive indication of the ability of fish to replace lost growth during the maintenance period. This result provides a very positive picture in multiple ways because it does not only contribute as a knowledge of growth compensation in cultured fish [24], but also to *C. ignobilis* in this study. This is very important because scientific research on compensatory growth has actually been carried out for a long time, although there is very little information on the growth patterns of fish when they hungry, and then given very little food.

Cultivation of *C. ignobilis* has been carried out in India and recorded significant weight gained over 9 months [25]. The initial records on the size of these fish at the time of being kept were only 6.0 ± 0.5 cm (TL). Although information on the initial weight of fish is not reported, the reported of feed Conversion Rate (FCR) value is 1.6 which is also not much different from the results measured in this study. Analysis of the amount of feed conversion (FCR) in this study obtained for T3 treatment was 1.01, for T4 treatment 0.93, for T5 treatment 0.92 and control 1.46, respectively. A low FCR value in T3 treatment, approaching a value of 1 means that the fish are more efficient in utilizing feed for growth, especially if it is smaller than 1 as in T4 and T5 treatments which indicates that the amount of feed needed is less to obtain normal growth.

At the end of this study, an evaluation was carried out on the condition factors that could provide an indication of the fitness status of bubara fish *C. ignobilis*, so the value for each treatment were 1.38 (T3), 1.39 (T4), 1.32 (T5) and 1.44 (Control). If these results are compared with the assessment standards adopted from salmon, the factor value of the bubara fish condition is in the range of 1.20 - 1.40 which states that the fish's condition is fairly good to good or in very balanced status. It is [26] introduced a classification of condition factors in salmon and assigned 5 categories with a scale of 0.80 as extremely poor to excellent conditions with a value of 1.60. This comparison may not be precise because Salmon is anadromous fish and lives in temperate waters so this comparison may not be correct. However, the use of this category is only a rough description. In addition, research on the condition factors of bubara fish *C. ignobilis* also seems to be still lacking so that it is difficult to get an accurate comparison. However, [27] reported that the condition factors of bubara fish *C. sexfasciatus* originating from natural populations ranged from 1.1 to 1.5. This shows that the condition factors obtained in the cultivation are still within the same range. This comparison gives a positive signal that although the bubara fish *C. ignobilis* are in a cultured condition with the given treatment, they show fairly good adaptation.

Analysis of the average weight gain using the General Linear Model (GLM) with SPSS-25 software showed that this bubara fish gave no different responses to any given treatment (P = 0.173*). Supposing rearing time was included as one factor other than satisfaction factor in the same analysis model, the result shows a significant difference. This is not surprising in line with fish growth processes that occurred from time to time during this study. These results are also supported by analyzing of the compensation coefficient (CC) which shows the ability of bubara fish *C. ignobilis* to restore their ability to grow again after a period of depression due to fasting treatment [28, 23]. The weight gained of bubara fish *C. ignobilis* for each fasting treatment which shows changes in fish weight during the study period (Figure 2). It can be seen that the three treatments show a relatively similar growth pattern effect except on day 42, bubara fish in 5 days fasting and 5 days feeding (T5) treatment tends to grow faster (37.60 ± 34.33 cm) and is closer to the average weight of control value (51.41 ± 34.1 cm).

This can be interpreted that long-term fasting can gradually restore the lost weight [29]. It should be noted that on day 42, the fish in the three treatments seemed to experience a slight decrease in gained weight consistently and this event seems to be closely related to changes in water parameters, especially for temperature and salinity. It was recorded that the temperature was between 27 - 28 °C and the salinity ranged from 12 - 29 ppt. This condition coincides with prolonged and very high rainfall that has an impact on the feeding behavior of fish in the cage. Fish tend to be inactive at the feeding time, and it is interesting that if in a normal time at high temperature and high salt content, the fish always eat up the entire portion of the feed provided, but in this condition, there is always a leftover feed that is not consumed. In addition, it was
also noted that fish usually reach the satiation state in a relatively short time (< 2 minutes), but in this condition, fish require a relatively long feeding time (3-4 minutes). This means that there has been an increase in the depression time in the fish that should receive the feed at that time in accordance with the fasting time allocated.

![Graph showing changes in body weight (g) of bubara fish Caranx ignobilis with different fasting time during 70 days of rearing period.](image)

**Figure 2.** Changes in body weight (g) of bubara fish *Caranx ignobilis* with different fasting time during 70 days of rearing period.

Apart from the phenotypic changes reported, this study was also attempted to analyze the internal structure of the digestive tract histologically. Research on the internal structure of the digestive tract of fish has actually been a lot, especially for fish inhabitants freshwater [30, 31, 32], and some for marine fish [33]. It is interesting that the description of the internal structure of the bubara digestive tract, appears to have never been studied before. A preliminary description of five intestinal structure of *C. ignobilis* were dissected. The digestive tract in the form of intestine is then separated from the stomach and pyloric cæca, and preserved in 10% formalin fixative. Figure 3 shows the intestinal morphology of bubara fish *C. ignobilis* which is divided into stomach, anterior intestine, mid-intestine and posterior intestine.

![Image of the intestinal morphology of Caranx ignobilis](image)

**Figure 3.** Intestinal morphology of *Caranx ignobilis*
Five individuals of bubara fish taken at the beginning of the experiment before the treatment and five at the end of the experiment. Intestines were taken from each individual fish from each treatment, cleaned, measured, and weighed. The average length of fish intestines ranged from 5.1 – 8.1 cm (3 days fasting and 3 days feeding treatments) with a weight ranging from 2.1 - 5.0 g. Observation of histological tissue was carried out under a microscope. In this preliminary stage, observations are only made to get a general picture of the internal gut structure of the fish that have not fasted (Figure 4) and fasted (Figure 5). A measurement and calculation of intestinal villi have not been carried out due to limited equipment. It was concluded from these preliminary observations that there has been an internal change in the structure of the villi.

**Figure 4.** Photomicrograph of the anterior intestine section of bubara fish C. ignobilis before giving satiation treatment. Note that the number of villi is quite large and dense. Notes; TMU (muscular layer tissues), TSU (submuscular layer tissues), and TS (serous layer tissues) appears in the picture.

**Figure 5.** Photomicrograph of the anterior portion of the intestine of bubara fish C. ignobilis after receiving fasting treatment. Villi are short and have gaps. Note, TM (mucus tissues).

### 3.3. Waters parameters

Optimal seawater quality, especially around the research location is very important to encourage the growth of cultivated fish, because fish that were free living experience restrictions on their movement space so they feel uncomfortable in marine cages. The quality of water in the restricted area will also get worse because the same water is not only used for living but also as a place for food waste and metabolic waste. While the quality of water for aquaculture in the sea follows the quality standards of the Ministry of Environment No. 51 of 2004 [34], with the main parameters of optimal growth and supporting parameters as a result of the placement of floating cages. According to [35], the reduced water flow within the floating cages encourages the presence of biofouling organisms, while the high water flow velocity outside the cage (> 25 cm.sec⁻¹) will prevents biofouling. This situation needs to be anticipated, because the presence of biofouling organisms greatly inhibits fish growth as a result of obstructing the flow of dissolved oxygen needed by the
cultivated organism. The results of the analysis of water parameters during the study are as follows (Table 2):

**Table 2. Waters parameters around the research location**

| Parameter items         | Mean ± SD       | Reference |
|-------------------------|-----------------|-----------|
|                         | at surface      | 5 m depth |           |
| Temperature (°C)        | 30.90 ± 0.95    | 29.70 ± 0.99 | [35]     |
| Salinity (%)            | 31.60 ± 0.50    | 32.10 ± 0.76 | 33 – 34  |
| pH                      | 7.40 ± 0.04     | 7.80 ± 0.01 | 7 – 8.5  |
| Water flow (cm.min⁻¹)   | 215.20 ± 146.06 | 209.50 ± 142.29 | –        |
| Water clarity (cm)      | 11.450.70 ± 211.11 | 10.326.30 ± 320.38 | > 300 – 500 |
| Dissolved oxygen (mg.L⁻¹) | 8.40 ± 0.54     | 7.34 ± 0.32 | > 5      |
| Ammonia (ppm)           | 0.018 ± 0.0052  | 0.019 ± 0.0063 | 0.3      |
| Nitrates (ppm)          | 0.266 ± 0.026   | 0.375 ± 0.038 | 0.08     |
| Phosphates (ppm)        | 0.027 ± 0.005   | 0.032 ± 0.007 | 0.015    |

4. Conclusion

Several important things can be concluded with the successful of raising bubara fish in fasting conditions with highly survival rate. While until the end of this study, the bubara fish has not reached the harvest size, but the development was very positively that it was estimated that the harvest size could be achieved within the next three months. Fasting treatment that does not show any difference to the control indicates that feeding habit can be reduced and does not have to give feed every day. Thus cost saving while increased production can be achieved during fasting treatment. The longer fasting period tends to give closer result to the control, which is quite good but still leaves a question mark about the maximum length of fasting time fish can endure. Answering this question one requires further research not only to refine the current results but also to further deepen aspects that have not been studied concerning with changes in the structure of the internal digestive tract and also the hepatosomatic index of the liver.

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