Biological performance of African catfish *Clarias gariepinus* (Burchell, 1822) fingerlings fed with raw chicken entrails

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ABSTRACT

The African catfish *Clarias gariepinus* (Burchell, 1822) grows fast, feeds on a large variety of agriculture by-products and can be raised in high densities resulting in high net yields. It is therefore considered as a good candidate for aquaculture. Generally, the increasing aquaculture activities worldwide led to a more expensive feed costs, thus looking for alternative and cheaper feeds coupled with optimum feeding rate is a focus in aquaculture research field. This study therefore aimed to determine the most efficient feeding rate and the potential of raw chicken entrails as feeds for *C. gariepinus* in terms of fish weight increment (WI), specific growth rate (SGR), feed conversion ratio (FCR) and survival rate (SR). *Clarias gariepinus* were fed with chopped raw chicken entrails at three different feeding rates (3%, 4% and 5%) based on the average weight for 60 days. The fish weight continually increased regardless of the feeding rate, but generally, those that were fed at 4% and 5% of the body weight showed significantly higher WG (g), SGR (% day^{-1}) and better FCR. Regardless of the feeding rate, all fish attained 100% SR. The feeding rate of 4% is recommended due to its similar WI with those fed at 5% but showed better FCR at the end of the culture.

Keywords: chicken wastes, freshwater fish, growth parameters

INTRODUCTION

The costs of commercial aquatic feeds are currently increasing due to the growing numbers of aquaculture activities. It is therefore crucial to efficiently use the feeds during the aquaculture operation not only for the growth of the culture but also for economic reasons since improper food supplication directly affects the production cost (Mihelakakis et al. 2007). Thus, it is essential to optimize the feeding rate in the culture of all commodities. This optimization becomes one of the critical areas in the aquaculture research field for the reduction of the excessive feeds (Dong-Fang et al. 2003).

Each species with its respective developmental stage has varying feeding rates that is also influenced by the culture system, fish size, and the nutrients in the diet (Cho et al. 2003; Mihelakakis et al. 2007). Overfeeding could result to waste of food and the interruption of the water quality (Ng et al. 2000). With appropriate feeding rates, fish farmers could reduce the production cost, maximize the culture growth and manage the water quality for a successful farming operation (Aderolu et al. 2010; Marimuthu et al. 2011).

The African catfish *Clarias gariepinus* (Burchell, 1822) is a large eel-like fish usually of dark gray or black coloration on the back, with white belly and is locally known as "hito" and "pantat" belonging to family Clariidae (FAO 2010). It is hardy with an accessory air-breathing organ (labyrinth organ) and it is found to be suitable for both small-scale and commercial aquaculture since it does not require extreme efforts and costs and has faster growth rate (Goos and Richter 1996; FAO 2010). Generally, this fish is an omnivore feeding on insects, plankton, snails and plant matter in the natural water bodies (Uys 1989).

Clarias gariepinus commands high price when sold in the market and its production greatly increases (FAO 2010). The demand for catfish in the Philippines continued to increase with production volume ranging between 3,729.29 metric tons in 2016 and 5,420.77 metric tons in 2020 (PSA 2021). It also contributed an annual value of PHP 5.77 million in 2020 (PSA 2021).

Clarias gariepinus are usually reared in ponds or different types of tanks at different stocking densities (FAO 2010). For the extensive culture of this fish, the larvae are fed with cow brain and egg yolk after 4-6 days prior to stocking in fenced nursery ponds. The post-larvae are then fed with single ingredient or compounded feeds. Fingerlings are graded and harvested after 24-48 days and are transferred to the production pond or being sold by the farmers. Different systems are currently being used in growing the catfish including the traditional flooded ponds, pits or ditches, earthen ponds, tanks, raceways and even in cages.

Large numbers of indigenous raw materials from poultry by-product meal, blood meal, oilcakes, cereal by-products, vegetables and leaf meals are used in developing feeds for the culture of various fish species (Akand et al. 1991; Bhadra et al. 1997; Manuel et al. 2020). Chicken entrails are poultry by-product with potential use as feed to African catfish. Chicken is one of the most commonly consumed meat worldwide, given that it is considered acceptable in most religions and cultures. The world's poultry meat per capita consumption is reported to increase more than threefold and is projected to reach up to 45.3 kg capita^{-1} by 2030 (FAO 2003). In Western Visayas, Philippines, the number of dressed chickens in poultry plants reached up to 44.8 million metric ton (PSA 2019). This also equates to the amount of the chicken by-products every day from the slaughterhouses. Edible chicken by-products include heart, liver, spleen and kidney. These constitutes significant ratio of live chicken weight ranges from 5-6% (Ockerman and Basu 2004). Aside from the kidney and intestines which are being grilled and eaten by humans, other components of the chicken entrails could be used as feeds. Dried chicken intestines contain protein (59.58%), lipid (17.78%), ash (6.79%) and nitrogen free extract (15.85%) (Nahar et al. 2000). Other internal parts of the chicken like liver, cecum, crop, heart, duodenum and lungs contain significant amounts of protein, vitamins, fatty acids, amino acids and minerals (Seong et al. 2015).

This study therefore aimed to determine the most efficient feeding rate and the potential of raw chicken entrails as feeds for *C. gariepinus*. Specifically, it aimed to identify the optimum raw chicken entrails feeding rate to *C. gariepinus* in terms of weight increment (WI), specific growth rate (SGR), feed conversion ratio (FCR) and survival rate (SR).

METHODS

This study was conducted in a private earthen fish pond in Brgy. Lanot, Roxas City Capiz Philippines. The 6 x 4 x 1.5 m freshwater-filled outdoor ponds were installed with nine adjacent 1 x 1 x 2 m hapa nets. The edges of the nets were fixed at 0.5 m away from the sides of the pond and the bottoms were lifted to 0.5 m from the pond substrate. These hapa nets served as compartments for particular treatment replicates.

Feed Preparations

For the feed preparation, raw chicken entrails were taken from VECS Poultry Processing at Brgy. Mianay, Ivisan Capiz Philippines. These were washed, chopped into 2.00 ± 1.00 mm and stored in a freezer (-4 ± 4°C) until use. Three treatments at 3% (T1), 4% (T2) and 5% (T3) wet weight (w/w) feeding rates were prepared based on the weight of *C. gariepinus*.

Rearing and Monitoring of *C. gariepinus*

Ninety pieces African catfish fingerlings with an average (± SEM) total length and weight of 5.14 ± 0.16 cm and 50.67 ± 1.51 g respectively were obtained from the local private hatchery in Brgy. Lanot, Roxas City, Capiz. Conditioning was done in a pond for 45 days by feeding the fish with commercial fry mashed feeds containing 38% crude protein. After conditioning, *C. gariepinus* fingerlings were stocked in hapa nets within an earthen pond at a density of 10 fish 0.6 m^{-3} assigned through a complete randomized design (CRD) each with three replicates. The stocks were fed with the prepared and thawed for 1-2 h chicken entrails twice a day, every 0800 h and 1700 h based on the assigned feeding treatments (3%, 4% and 5% of the body weight) for 60 days. Samplings were done every after 15-day period. These were done by lifting each hapa net from the water and scooping the pooled fish with a plastic bucket. From the pooled stock in a bucket, each fish was transferred in a plastic container for individual weighing using a stainless meshed scoop.

Statistical Analysis

Average ± standard error of mean (SEM) of the WG, SGR, SR and FCR were computed using the software Statistical Package for Social Sciences (SPSS) version 20. The same software was used to compare the treatments. The growth and feed efficiency data were tested for homogeneity of variance using Levene's tests and then subjected to one-way analysis of variance (ANOVA) at 0.05 level of significance to determine the differences between the three treatments. Furthermore, post-hoc Tukey's tests were carried out to confirm where the differences between the groups occurred.

RESULTS

Weight Increment

The WI were steadily increasing with a slight reduction on the 45th day, followed by a sharp trend towards the 60th day. At day 15, those fed at 3% rate had lower WI at 0.97 ± 0.13 g compared to those that were fed at 4% and 5% with 1.90 ± 0.00 g and 1.57 ± 0.07 g, respectively. At day 30, however, those fed at 3% and 5% rate showed significantly higher WI than those fed at 4% rate. At day 45, all treatments showed significant differences in WI having those fed at 5% to be highest, followed by those fed at 4% and the lowest increment was observed to those fed at 3% rate. At the end of the culture period, 4% and 5% appeared to have the highest WI at 35.40 ± 0.45 g and 36.00 ± 0.29 g, respectively. The lowest WI was found in *C. gariepinus* fed at 3% rate at 30.40 ± 0.12 g (Figure 1).

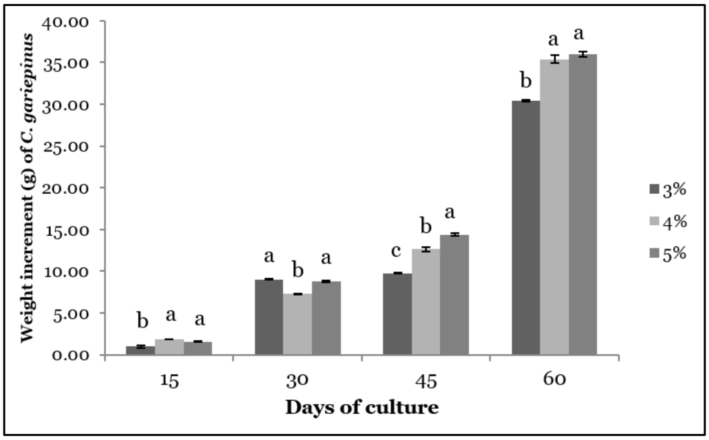

Figure 1. Weight increment of *Clarias gariepinus* fed raw chicken entrails at 3%, 4% and 5% feeding rate. Data presented as mean ± SEM ($P < 0.05$).

Specific Growth Rates

The SGR of *C. gariepinus* showed a consistent increase within the culture period. Highest SGR was found in fish with 5% feeding rate at day 45 and 60 of the culture reaching up to 3.21 ± 0.01% day^{-1} and 3.96 ± 0.01% day^{-1}, respectively. This is followed by those at 4% feeding rate with SGR of 3.10 ± 0.01% day^{-1} and 3.90 ± 0.01% day^{-1} at days 45 and 60 respectively. Those at 3% feeding rates appeared to have the lowest SGR at day 45 and 60 with 3.05 ± 0.00% day^{-1} and 3.81 ± 0.00% day^{-1}, respectively.

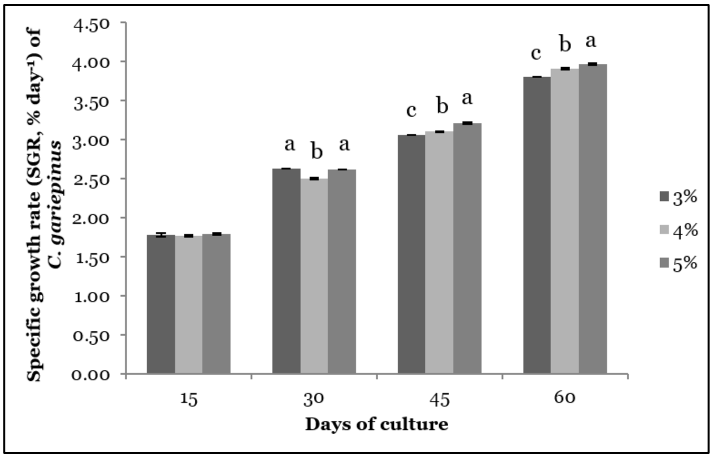

Figure 2. Specific growth rate (SGR, % day^{-1}) of *Clarias gariepinus* fed raw chicken entrails at 3%, 4% and 5% feeding rate. Data presented as mean ± SEM ($P < 0.05$).

Feed Conversion Ratio

The FCR was relatively higher on the first 15 days, requiring 1.54 to 3.23 kg of feeds to convert a kilogram of fish. However, the FCR improved in the succeeding sampling events, only requiring 0.78 to 1.17 kg of feed to produce a kilogram of fish. At the end of the culture period, T2 (4%) had significantly better FCR compared to the other treatments (Table 1).

No mortality was observed throughout the culture period resulting to 100% survival rates in all treatments.

Table 1. Average (± SEM) feed conversion ratio (FCR) of *Clarias gariepinus* fed with raw chicken entrails at 3%, 4% and 5% feeding rates. Values with the same superscripts in every feeding rate at the same culture period are not significantly different ($P < 0.05$).

Treatment (Feeding Rate %)	Days of Culture			
	15	30	45	60
T1 (3)	3.23 ± 0.47^{a}	0.78 ± 0.01^{b}	1.17 ± 0.00^{a}	0.83 ± 0.00^{a}
T2 (4)	1.54 ± 0.01^{b}	0.85 ± 0.01^{a}	0.94 ± 0.01^{b}	0.79 ± 0.00^{b}
T3 (5)	1.93 ± 0.08^{b}	0.79 ± 0.01^{b}	0.93 ± 0.01^{b}	0.82 ± 0.00^{a}

DISCUSSION

Weight Increment

The WI of the fish continued to increase from the start up to the end of the culture period (Figure 1). This was probably attributed by the sufficient protein content, vitamins and minerals in the fed chicken entrails (Nahar et al. 2000; Seong et al. 2015). Those at 3% FR, however, showed lower WI after 15 days and from day 45 up to the end of the culture. Furthermore, an unusual result at day 30 appeared showing that the WI of the fish fed at 4% feeding rate was lower compared to those fed at 3% and 5%. This incident is similar to the results of the study conducted by Tiamiyu et al. (2018) showing that *C. gariepinus* fed at 10% feeding rate obtained lower mean WI than those fed at 5% and 15% feeding rates. This was probably attributed to the fish behavioral, physiological and structural responses to utilize the energy reserves to compensate their metabolic requirements during starvation or feed restriction (Navarro and Gutierrez 1995.) At day 30, the fish fed at 4% feeding rate probably experienced decrease on the overall condition factor which, perhaps exhibited the changes in lipid content, blood metabolites, muscle and organ mass that have possibly resulted to a decreased growth. However, when feeding resumed until day 45, the fish probably exhibited faster growth rate known as compensatory or catch-up growth up to the end of the culture period (Ali et al. 2003). Also, 4% and 5% feeding rates have higher growth increment at the end of the culture period reaching up to 35.40 ± 0.45 g and 36.00 ± 0.29 g respectively. This confirmed that the fish weight has generally linear increase with the increasing feeding rate and the chicken entrails significantly affected the growth performance of the fish in general (Marimuthu et al. 2011). Given the duration of this study, the result of the WI is comparable to that of Nahar et al. (2000) where *C. gariepinus* attained 69.6 ± 0.17 g WI after 120 days of culture. This is also similar to those conducted with juvenile bagrid catfish (*Mystus nemurus*), Europen sea bass (*Dicentrarchus labrax*), Channel catfish (*Ictalurus punctatus*) and Pacu (*Piacartus mesopotamimus*) wherein higher WI were exhibited when given more amounts of feeds than those fed with lesser amounts (Borghetti and Canzi 1993; Ng et al. 2000; Eroldogan et al. 2004; Robinson and Li 2007). The result of the study conducted by Nahar et al. (2000) on *C. gariepinus* fed with chopped raw chicken intestine showed increased mean WI for the first two months only and there was a gradual decline thereafter. This study on the other hand, showed continuous increase in mean WI from the start up to the 60-day culture. However, this study showed lower mean WI (36.00 ± 0.29 g) compared to the study of Nahar et al. (2000) that reached a maximum of 53 g.

Specific Growth Rate

The SGR recorded in this study directly reflected the results of the WI. Those at 4% and 5% feeding rate showed higher SGR at days 45 and 60, while those at 3% feeding rate had lower SGR (Figure 2). The result of this study on 5% feeding rate (3.90 ± 0.01% day^{-1}) is relatively similar to those conducted by Marimuthu et al. (2011) at 3.39 ± 0.17% day^{-1} but higher compared to the study of Tiamiyu et al. (2018) with an SGR of 2.28 ± 0.19% day^{-1} with both studies also at 5% feeding rates. It further showed that the higher the amounts of feeds given to the fish, the better the SGR. This is further supported by the result of the study conducted by Sun et al. (2006) showing that cobia (*Rachycentron canadum*) fed 7% of the body weight had higher SGR than those fed 3% body weight per day.

Feed Conversion Ratio

The ability of the *C. gariepinus* to convert the feeds into flesh in this study was measured through its FCR. The observed improvement in the FCR after 15 days of culture (Table 1) could have been due to various factors, but one major reason could be the adjustment of the diet from commercial fry mashed during the conditioning to chicken entrails. Generally, it appeared that *C. gariepinus* fed at 4% and 5% feeding rates had better FCR ranging from 0.79 ± 0.00 to 1.93 ± 0.08 compared to those fed at 3% of the body weight, suggesting that this species could efficiently convert the raw chicken entrails into fish flesh.

Usually, the FCRs of the cultured fishes were above 1.0, but some lower values were obtained from this study. According to USAID (2011), it is possible to have an FCR lower than 1.0 since the fish contains water in its flesh while the feeds used were dry and contain minimal amount of water. When the fish, therefore, converted the dry feeds into moist flesh using a highly efficient diet, it could produce heavier moist flesh than the weight of the dry feeds used. Another possible reason for this was the high density of natural food present in the culture system that could have been consumed by the fish. A study conducted by Hender et al. (2021) on *Lates calcarifer* (Bloch, 1790) fed diets containing Black soldier fly also resulted to FCRs between 0.73 ± 0.02 and 0.78 ± 0.02. Another study conducted by Nhu et al. (2015) also resulted to Snakeskin gourami FCRs between 0.4 and 0.6 when fed with pig manure or its digestate with carbohydrate-rich pelleted feeds.

The results of the FCRs in this study were comparable to those conducted by Marimuthu et al. (2011) on *C. gariepinus* fed commercial feeds (38% protein) at 8% feeding rate which resulted to an FCR of 1.00 ± 0.09. Tiamiyu et al. (2018) reported a lower FCR of 2.69 ± 0.16 for *C. gariepinus* fed with commercial diets at 5% FR. In addition, Anderson and Fast (1991) described that if the feed ration was greater than the optimum feed level, this could result to the increased food waste and FCR. In this study, the maximum feeding rate used was 5% but the result of the FCR of *C. gariepinus* fed at this rate is comparable to those fed at 4% body weight and in general did not result to higher FCR. These further showed that raw chicken entrails were efficient and suitable diet since only few amounts were required to produce a unit WI (Nahar et al. 2000). However, the total amount of feeds given to the fish was also not expected to be totally converted into flesh since these organisms were not completely efficient feed converters (Tiamiyu et al. 2018). This is because some of the energy from the feed is used by the fish first for metabolic activities including digestion, respiration, nerve impulses, salt balance, swimming and other life activities (Craig and Helfrich 2009). In this study, however, only few amounts were necessary for the production of fish flesh. This study therefore, recommends the use of raw chicken entrails for *C. garieipinus* at 4% feeding rate since it has similar WI with those fed at 5% of the body weight but showed lower FCR at the end of the culture. This could limit the rations of feed while still achieving acceptable long-term growth trajectories leading to a minimized feeding cost.

Feeding *C. gariepinus* with raw chicken entrails did not only result to increased growth rate and lower FCR but also showed 100% SR. This result was higher compared to the studies of Nahar et al. (2000) and Tiamiyu et al. (2018) which achieved a SR of 95.0 ± 5.00 % and 83-96% SR respectively. This is an indication that raw chicken entrails fed to the fish did not contain harmful elements that could cause culture mortality. Furthermore, though the water parameters were not monitored in this study, 100% SR was an indication that the cultures were not overfed that could alter the optimum condition which might also lead to mortality. Nonetheless, it is still recommended to monitor the water parameters such as temperature, pH, and ammonia levels of the culture system to confirm the effects of the chicken entrails to the water quality. It is also recommended to include proximate analyses for this raw feed.

Lastly, it is important to note that the related studies mentioned were conducted in concrete or earthen ponds but none in hapa nets. Using this new protocol, however, resulted to comparable biological performance of the African catfish in general. Also, using the hapa nets in this study provided ease on culture management in terms of feed distribution and monitoring and catfish sampling and harvesting. For the feed distribution, using hapa nets have eliminated the probability of the feeds to have a direct contact with the soil or concrete substrates which could increase its contamination with the organic matter. The volume of uneaten feeds could easily be monitored by lifting the net. For the sampling and harvesting, the stocks could be pooled, scooped or transferred easily to a container or weighing scale by also lifting the hapa nets.

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