RESEARCH ARTICLE

A STUDY ON THE GROWTH PARAMETERS OF *CTENOPHARYNGODON IDELLA* WITH RESPECT TO VARIOUS FEEDS

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DOI: https://doi.org/10.5281/zenodo.17214351

Abstract:

Ctenopharyngodon idella (grass carp) is an important aquaculture species valued for its rapid growth and adaptability to diverse feeding regimes. The present study evaluated the growth performance, specific growth rate (SGR), and feed conversion ratio (FCR) of grass carp under three dietary treatments: plant-based feed (maize and rice bran), animal-based feed (fish meal), and a locally available commercial aquarium feed. The experiment was conducted for 35 days in triplicate tanks (30 × 25 × 14 cm), each stocked with juvenile grass carp (initial length: 4–5 cm; weight: 2–3 g). Fish were fed daily at 2% of body weight. Results showed significant variation among treatments, with the highest SGR observed in fish fed plant-based feed, while the lowest SGR was recorded in fish fed animal-based feed. Conversely, FCR values were highest in the animal feed group and lowest in the plant feed group, indicating better feed utilization efficiency with plant-based diets. These findings suggest that low-cost plant-based diets can enhance growth performance and feed efficiency in grass carp aquaculture, offering a sustainable alternative to animal-based feeds.

Keywords: Grass Carp, Specific Growth Rate, Feed Conversion Ratio, Aquaculture.

Introduction:

Background of the Problem

Aquaculture has emerged as the fastest-growing sector in global food production, currently providing more than half of the fish consumed worldwide (FAO, 2022). Fish are a rich source of high-quality animal protein and long-chain omega-3 fatty acids, as well as essential micronutrients including iodine, vitamin D, and calcium, which are indispensable for human health (Tacon and Metian, 2013). With the global population projected to reach nearly nine billion by 2050, aquaculture is expected to play a pivotal role in ensuring food and nutritional security. Meeting this growing demand requires the

refinement of aquaculture practices, particularly in the domain of feed and nutrition, which directly influence growth performance and production efficiency.

Nutrition represents the cornerstone of sustainable aquaculture, as feed accounts for the largest proportion of production costs (NRC, 2011). In semi-intensive and intensive culture systems, natural food sources are insufficient to sustain optimal fish growth, necessitating the supplementation of formulated feeds. The formulation, composition, and efficiency of these feeds critically determine growth performance, feed utilization, and overall profitability of aquaculture operations (De Silva and Anderson, 1995).

Grass carp (*Ctenopharyngodon idella*), belonging to the family Cyprinidae—the largest freshwater fish family—has considerable economic and ecological significance. Native to East Asia, this species has been introduced worldwide, primarily for the biological control of aquatic weeds in ponds, reservoirs, and irrigation canals (Opuszynski and Shireman, 1995). Beyond its utility in aquatic weed management, grass carp is valued as a cultured species due to its rapid growth, herbivorous feeding habit, adaptability to varied culture systems, and role as an affordable source of animal protein for human consumption (FAO, 2020).

The evaluation of growth performance in aquaculture relies on quantifiable parameters such as length increment, weight gain, average daily growth rate (ADGR), specific growth rate (SGR), and feed conversion ratio (FCR). Among these, SGR is a widely applied index, as it provides a standardized measure of growth efficiency over a given time period (Hopkins, 1992). Likewise, FCR is a fundamental indicator of feed utilization efficiency, expressing the ratio of feed intake to biomass gain (NRC, 2011). Both indices are indispensable for assessing the biological and economic efficiency of feed regimes.

Optimization of growth parameters and feed efficiency in *C. idella* is therefore critical for enhancing production sustainability and reducing costs in aquaculture. The present study aims to evaluate the growth performance, specific growth rate, and feed conversion ratio of juvenile grass carp under different dietary treatments, thereby contributing insights into cost-effective feeding strategies for this important aquaculture species.

Objectives:

The primary objective of the present study is to investigate the growth performance of juvenile *C. idella* under three dietary regimes, with particular emphasis on specific growth rate (SGR) and feed conversion ratio (FCR). This work aims to identify cost-effective and nutritionally efficient feeding strategies for sustainable grass carp aquaculture.

Materials and Methods:

Experimental Design

The study was conducted using three experimental tanks designated as T1, T2, and T3, each with dimensions of 30 × 25 × 14 cm. Juvenile *C. idella* (grass carp) of uniform size (average length: 4–5 cm; average weight: 2–3 g) were stocked at a density of five individuals per tank. Each treatment was maintained with five replicates to ensure reliability of results.

Feed Formulation and Feeding Protocol

Three types of feed were prepared and administered:

- **T1 (Plant-based feed):** A mixture of rice bran and maize in a 1:1 ratio. Fresh maize was steam-cooked, ground, and mixed with rice bran, followed by drying and pelletizing.
- **T2 (Animal-based feed):** Sardine (*Sardinella* sp.) was used to prepare fish meal. The fish were cleaned, steam-cooked, dried, ground, and pelletized into a uniform diet.
- **T3 (Commercial feed):** A locally available floating-type aquarium feed purchased from the market.

Fish in all treatments were fed daily at 2% of their body weight, adjusted according to periodic weight measurements. Feeding was conducted twice daily to minimize wastage and ensure adequate consumption.

Data Collection

The initial length and weight of each fish were recorded prior to stocking. Length was measured using a standard ruler, and weight was determined using a digital weighing balance (precision ±0.01 g). Growth measurements were taken at 7-day intervals (7^{th}, 14^{th}, 21^{st}, 28^{th}, and 35^{th} day).

Growth Performance Parameters

The following growth indices were calculated after the 35-day experimental period:

Specific Growth Rate (SGR, % day^{-1})

$$SGR = In\ (Wf) - In\ (Wi)/t \times 100$$

Where Wf= final body weight (g) Wi= initial body weight (g) t = duration of experiment days

Feed Conversion Ratio (FCR)

$$FCR = \text{Feed intake(g)}/\text{Weight gain(g)}$$

Where feed intake = total feed supplied,and weight gain= difference between final and initial biomass.

Nutritional Composition of Feeds

The proximate composition of plant-based feed, animal-based feed, and commercial feed was determined following the standard methods of the Association of Official Analytical Chemists (AOAC, 2016). Parameters analyzed included crude protein, crude fat, ash, moisture, and crude fiber content.

Statistical Analysis

Data were analyzed using one-way ANOVA to test for significant differences among treatments, followed by Tukey's post hoc test where applicable. Statistical significance was set at $p < 0.05$.

Results:

Specific Growth Rate (SGR)

The specific growth rate (SGR) of *C. idella* showed marked variation among the different dietary treatments over the experimental period (Table 1). The highest SGR values were consistently observed in fish fed the plant-based diet, followed by those fed the commercial aquarium feed, while the lowest SGR was recorded in fish provided with the animal-based diet.

During the first week (0–7 days), SGR peaked in the plant feed group (1.72 % day^{-1}), indicating rapid adaptation and efficient utilization of the diet. By contrast, the lowest SGR across the experiment

was observed in the animal feed group during the third week (14–21 days; 0.11 % day^{-1}). Across the 35-day trial, plant feed maintained relatively higher SGR values compared with the other treatments, suggesting superior suitability for juvenile grass carp growth.

Table 1: Specific Growth Rate (SGR, % day^{-1}) of *C. idella* fed different diets

Days	Plant Feed	Animal Feed	Aquarium Feed
0-7	1.72	0.17	0.246
7–14	0.989	0.179	0.322
14–21	0.301	0.110	0.248
21–28	0.450	0.143	0.309
28–35	0.420	0.195	0.335

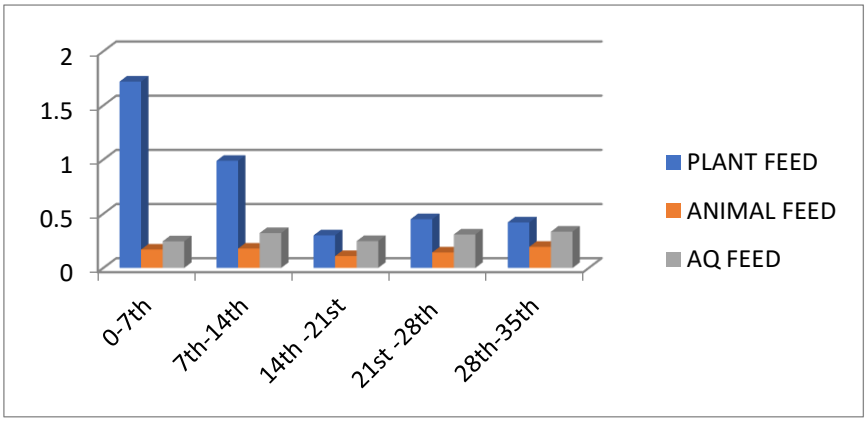

Figure 1: Specific Growth Rate (SGR, % day^{-1}) of *C. idella* fed different diets

Feed Conversion Ratio (FCR)

Feed conversion ratio (FCR) displayed an opposite trend to SGR (Table 2). The lowest FCR values were consistently recorded in the plant feed group, while the highest values were found in the animal feed group. This indicates that the plant-based diet supported more efficient feed utilization compared with both animal-based and aquarium feeds.

The highest FCR (13.90) occurred in the animal feed group during the fourth week (21–28 days), suggesting poor conversion efficiency of fish meal-based diets for grass carp. Conversely, the lowest FCR (1.09) was observed in the plant feed group during the first week, reflecting optimal utilization of the maize–rice bran mixture.

Table 2: Feed Conversion Ratio (FCR) of *C. idella* fed different diets

Days	Plant Feed	Animal Feed	Aquarium Feed
0-7	1.091	11.66	8.04
7–14	1.952	11.07	6.135
14–21	1.586	6.897	3.514
21–28	4.367	13.90	6.385
28–35	4.607	10.14	5.893

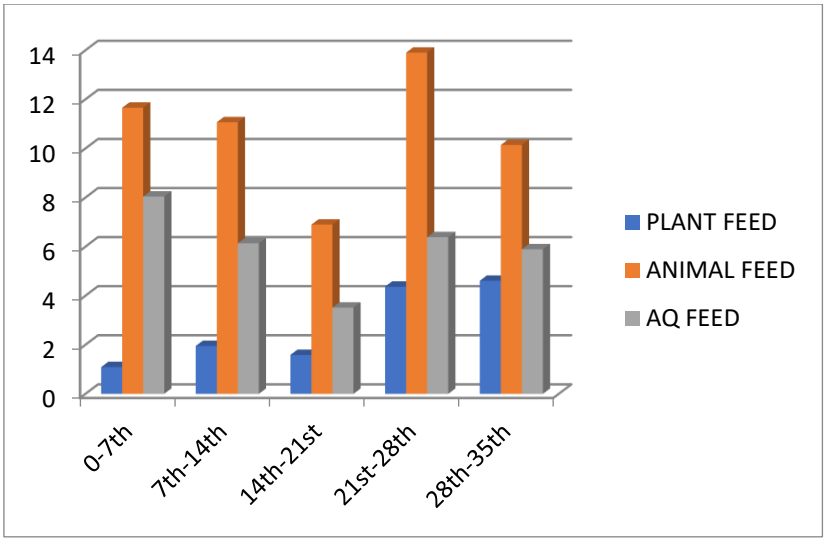

Figure 2: Feed Conversion Ratio (FCR) of *C. idella* fed different diets

Overall, the plant-based diet resulted in the highest SGR and lowest FCR, demonstrating superior growth performance and feed efficiency. In contrast, the animal-based diet produced the poorest results in both indices. The commercial aquarium feed provided intermediate values, indicating moderate suitability. These findings highlight the potential of plant-based diets (maize–rice bran) as a cost-effective and sustainable option for juvenile grass carp culture, in line with previous reports on herbivorous carps favoring plant-derived feeds (NRC, 2011; De Silva and Anderson, 1995).

Discussion:

In this 35-day trial juvenile *C. idella* fed the plant-based diet (maize : rice bran 1:1) showed the highest specific growth rate (SGR) and the lowest feed conversion ratio (FCR). Fish offered the commercial aquarium feed had intermediate performance, whereas the group fed the fish-meal (animal) diet showed the lowest SGR and the highest FCR. These results indicate that, for the juveniles used in this experiment, the maize–rice bran formulation promoted more efficient somatic growth and feed use than the high-protein fishmeal diet.

Several physiological traits of grass carp likely underlie the superior performance on the plant diet. *C. idella* is a typical herbivorous cyprinid with a relatively long intestine and a simplified (stomachless) gut morphology, adaptations that favour digestion of plant materials and fermentation of complex carbohydrates rather than rapid gastric digestion typical of carnivores. Intestinal evacuation in juvenile grass carp is relatively rapid (reported ≈12 h for formulated diets), reflecting an evolutionary strategy to process low-energy plant matter through frequent intake and fast gut throughput. These anatomical and functional characteristics can enhance the efficiency with which grass carp extract energy and nutrients from processed plant ingredients such as cooked maize and rice bran, and help explain the greater SGR and lower FCR observed with the plant feed in the present trial.

Reported digestibility data indicate that rice bran and maize derivatives can be well-digested by grass carp when processed appropriately. Processing steps used in this study (steam-cooking maize, grinding, drying and pelletizing) increase starch gelatinization and protein availability, improving nutrient accessibility and palatability; this can raise apparent digestibility and effective metabolizable energy of plant feeds. In contrast, a single-ingredient fishmeal feed, though high in crude protein, may

not match the energy-to-protein balance, amino-acid needs, or feeding behavior of herbivorous juveniles. Thus, despite higher crude protein content in fishmeal, effective nutrient utilization (and hence growth) can be poorer if the overall diet does not fit the species' digestive and metabolic profile. Evidence from digestibility trials supports good dry matter and protein digestibility of rice bran and maize fractions in grass carp diets when appropriately processed.

High crude protein alone does not guarantee better growth; optimal protein requirements are stage- and temperature-dependent for grass carp. Recent studies estimate juvenile/sub-adult protein requirements in the mid-20s to high-30s percent range (depending on temperature and experimental design), rather than approaching the crude protein levels typical of raw fishmeal (which may be >60% crude protein). Excess dietary protein beyond the species' requirement can be energetically costly (increased deamination and excretion) and may reduce net protein deposition efficiency, thereby raising FCR. These considerations could help explain why the fishmeal treatment produced higher FCRs despite its high protein content.

Physical properties of pellets (bulk density, floatability, water stability, fines generation) and palatability strongly influence voluntary feed intake and waste. Poorly formed pellets, rapid disintegration, or a mismatch between pellet behavior (floating vs. sinking) and the species' feeding habits can increase feed loss and apparent FCR even when the feed has high nutritional value on paper. In this experiment the plant feed was prepared as steamed and re-pelletized material which may have had favourable physical characteristics and palatability for grass carp, whereas the fishmeal pellets (as prepared here) may have produced more fines, leached nutrients, or been less attractive — all of which elevate measured FCR. Studies on pellet physical quality and palatability show large effects of pellet form and processing on feed utilization and waste.

The observed decrease in weekly SGR with time (after an initial high in week 1) is consistent with the well-known pattern that relative growth rate declines as fish increase in size: SGR is inversely related to body mass because absolute growth and metabolic scaling change as animals grow. Therefore, some decline in percentage SGR over successive weeks is expected and should be accounted for when comparing treatments: the relevant comparison is the relative performance among diets at similar size ranges rather than absolute SGR values alone.

Taken together, the data indicate that a well-processed plant-based feed (maize + rice bran) can be more appropriate and cost-efficient for juvenile grass carp than a single-ingredient fishmeal diet, because (1) grass carp are adapted to process plant material; (2) processed plant ingredients can be highly digestible for this species; and (3) feed physical form and nutrient balance (energy:protein ratio, amino acid profile, mineral content) strongly affect observed growth and FCR. For smallholder or low-cost production systems, use of locally available plant feedstuffs (properly processed and pelletized) may therefore offer both economic and biological advantages.

Limitations of the Study and Recommendations for Further Work

The present experiment used a modest sample size and a 35-day period in small tanks; extrapolation to pond or cage production should be cautious. To strengthen the conclusions, future trials should:

1. Measure apparent digestibility coefficients (ADC) of the test diets (dry matter, protein, lipid, starch) to quantify true nutrient availability.
2. Analyse amino-acid profiles and the energy:protein ratio of each feed to detect imbalances.
3. Standardize and report pellet physical properties (floatability, water stability, pellet durability index, fines%) because these directly affect intake and FCR.
4. Monitor water quality (NH_3, NO_2^-, DO, temperature) and mortality to rule out environmental confounders.
5. Increase replication, extend duration to cover more growth stages, and include enzyme activity or gut micro biota analyses (amylase, cellulase, protease) to link digestive capacity with feed response. Studies indicate that grass carp gut enzyme activities (amylase, cellulase) and microbiota composition are important determinants of plant-feed utilization and would be informative in follow-up experiments.

Conclusion:

The findings support the suitability of a processed maize–rice bran diet for juvenile grass carp under the conditions tested, manifested as higher SGR and lower FCR compared with a single-ingredient fishmeal diet. These results are consistent with grass carp's herbivorous physiology and with literature showing good digestibility of properly processed plant ingredients for this species. Confirmatory trials with digestibility assays, pellet quality control, and larger, pond-scale trials are recommended before broad practical adoption.

The present study demonstrates that feed type has a significant influence on the growth performance of grass carp (*C. idella*). Among the tested diets, plant-based feed (rice bran and maize mixture) resulted in superior growth performance compared to fishmeal and commercial aquarium feed, despite its lower crude protein content. This outcome can be attributed to the herbivorous feeding behavior and stomachless digestive physiology of grass carp, which are better adapted to utilize plant-based diets efficiently.

Although fishmeal provided the highest protein concentration, its utilization was limited, leading to reduced growth and feed conversion efficiency in grass carp. This finding suggests that while fishmeal remains an important dietary protein source for carnivorous and omnivorous fishes, it may not be an economically or biologically efficient feed option for herbivorous species such as grass carp.

The study also highlights the importance of growth indices such as Specific Growth Rate (SGR) and Feed Conversion Ratio (FCR) as reliable indicators for evaluating feed efficiency in aquaculture nutrition trials. Optimization of feed formulation in accordance with the species-specific feeding ecology not only enhances growth performance but also ensures cost-effectiveness and sustainability in aquaculture systems.

Future research should focus on refining plant-based feed formulations, incorporating locally available ingredients, and exploring the role of feed additives or probiotics in improving nutrient digestibility and overall growth performance of grass carp.

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