International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2024: 7.101

Growth Performance in Neon Tetra (*Paracheirodon innesi*) Fed with Different Diet Formulations

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Abstract: ***Neon tetra (Paracheirodon innesi) is a brightly coloured ornamental fish of the family Characidae, widely maintained in freshwater aquaria for its vivid coloration and tolerance to a range of water conditions. This study evaluated the effects of dietary phytoextracts of Spirulina, Ashwagandha, and Moringa using different diet concentrations supplemented along with commercial feed for experimental durations to assess the growth performance and use of feed in neon tetra. Growth performance was analysed in terms of body weight, total length, Specific Growth Rate (SGR%), and Feed Conversion Ratio (FCR%). All groups showed significantly improved growth and feed efficiency compared with the control. Ashwagandha at 1.00% (A3) resulted in increased body weight, length, and exhibited higher SGR values. In contrast, FCR decreased in A3 compared to the control. Spirulina and Moringa based diets revealed moderate, consistent, progressive improvements in SGR and FCR with respect to the control. No side effects were observed in any experimental groups. The above findings demonstrate the potential of Ashwagandha, Spirulina, and Moringa phytoextracts as natural growth promoters in ornamental fish nutrition. Adoption of such plant-based additives may improve feed utilization, growth promoters, and support more economically sustainable and eco-friendly ornamental aquaculture practices.***

Keywords: Neon Tetra (*Paracheirodon innesi*), Ornamental fish, Formulated feeds, Growth performance, Ashwagandha, *Spirulina*, *Moringa*, Phytoextracts

1. Introduction

Ornamental fish farming has emerged as a significant global sector due to its high economic value and increasing popularity as a hobby. In the Indian subcontinent, ornamental fishes offer a promising alternative livelihood option, particularly for economically vulnerable coastal and island communities, including those in the Sundarbans region, where they can help improve household income and living standards [2] [5] [6] [7] [8] [13]. By promoting the culture of ornamental species for domestic and export markets, the economic status of these communities can be upgraded, given the strong internal demand and expanding international trade potential. The rapid growth of the ornamental fish industry in recent years highlights the need for balanced, nutritionally optimized diets to support fish health, coloration, and market value. The neon tetra (*Paracheirodon innesi*), a widely favoured ornamental species, is known for serving as an excellent model for assessing growth performance as an indicator of physiological health, nutritional status, and environmental adaptability.

Plants serve as rich, cost-effective sources of safer chemical compounds with properties such as anti-stress, growth promotion, appetite stimulation, immune stimulation, aphrodisiac effects, and anti-pathogen activity in fish aquaculture. These plant products lower treatment costs, enhance environmental friendliness through biodegradability, and reduce parasite drug resistance due to molecular diversity [4]. As dietary supplements, they minimize the risks associated with chemical drugs and offer a promising method for disease control [10]. The continued growth of the ornamental fish sector highlights that the successful breeding and rearing of such species are strongly influenced by optimized dietary formulations, particularly appropriate protein levels, which are crucial for achieving improved growth, higher survival rates, and enhanced reproductive performance.

Several studies underscore the importance of optimizing dietary protein levels in fish feeds for maximal growth and nutrient utilization. For instance, [9] demonstrated that freshwater angelfish (*Pterophyllum scalare*) achieved optimal growth and feed efficiency with diets containing around 30% protein.

Phytoextracts such as *Spirulina*, Ashwagandha (*Withania somnifera*), and *Moringa* have attracted interest because of their immunostimulatory and growth-promoting influence in aquaculture species. However, optimal concentrations and their specific impacts on ornamental fish like Neon tetra remain largely unexplored. This study investigates the relationship between phytoextract supplementation levels and growth performance in Neon tetra under laboratory conditions.

2. Materials and Methods

2.1 Feed Formulation

The commercially available plant extracts were procured from local markets. The powdered plant extracts were mixed with commercial feed (Table 1), pelleted, dried, and then fed to the fish according to AOAC (2010).

Table 1: Feed composition used for fish during the experimental duration.

Sl. No.	Commercial Feed (mg)	Phytoextract (mg)	Conc. of Phytoextracts (%)	Symbol
1	52.8	0	0	Control (C)
2	52.536	0.264	0.50	S1, A1 & M1
3	52.272	0.528	0.75	S2, A2 & M2
4	52.008	0.792	1.00	S3, A3 & M3

2.2 Experimental Design

Juvenile Fish with an initial mean body weight of 0.25 ± 0.02 g was procured from local aquarium shops and acclimated in glass aquaria (25 L; $9 \times 9 \times 12$ inches), temperature 26 ± 1° C and photoperiod 12:12 h light: dark were maintained for fifteen days. Fish were fed with commercial diet once daily throughout the acclimation period.

By end of acclimation, 150 fish were randomly distributed into 10 glass aquaria, 15 in each, for the feeding experiment. Fish were fed daily at a ration level of 3% of their body weight. Uneaten feed and faecal matter were removed using a rubber siphon to avoid deterioration of water quality. Partial water renewal was carried out every 72 h by siphoning out waste and replacing it with 75% of fresh water, under the least stressful conditions.

Growth performance (body weight and length) was recorded at 60, 75, and 90 days of the experimental duration. Food Conversion Ratio (FCR) and Specific Growth Rate (SGR) were calculated and analysed.

2.3 Data calculation

The growth parameters were analyzed following the standard formula for weight gain (WG), length gain (LG), SGR, and FCR.

Body weight gain (BWG) = FBW - IBW

Body length gain (BLG) = Final body length - Initial body length

Feed Conversion Ratio (FCR%) = $\frac{Feed\ intake}{Weight\ gain}$

Specific Growth Rate (SGR%) = $\frac{\text{FBW}-\text{IBW X 100}}{Time\ (days)}$

Where, FBW = Final Body Weight (g),
IBW = Initial Body Weight (g).

2.4 Statistical Analysis

The design was planned and implemented in a completely randomized design. Statistical analysis of the data was performed using the SPSS program, version 19 (Richmond, VA, USA). The obtained data were subjected to one-way ANOVA followed by Duncan's multiple range test (Duncan, 1955) at a 95% confidence level. Differences between treatments were tested for significance ($P<0.05$).

2.5 Ethical Statement

Neon tetras, being an ornamental fish used in this study, were obtained from commercial aquarium shops. Ensuring their use complies with ethical guidelines for non-threatened species sourced from commercial suppliers.

3. Results

The growth performance of Neon tetra fed with different concentrations of *Spirulina*, Ashwagandha, and *Moringa* phytoextract-supplemented feed.

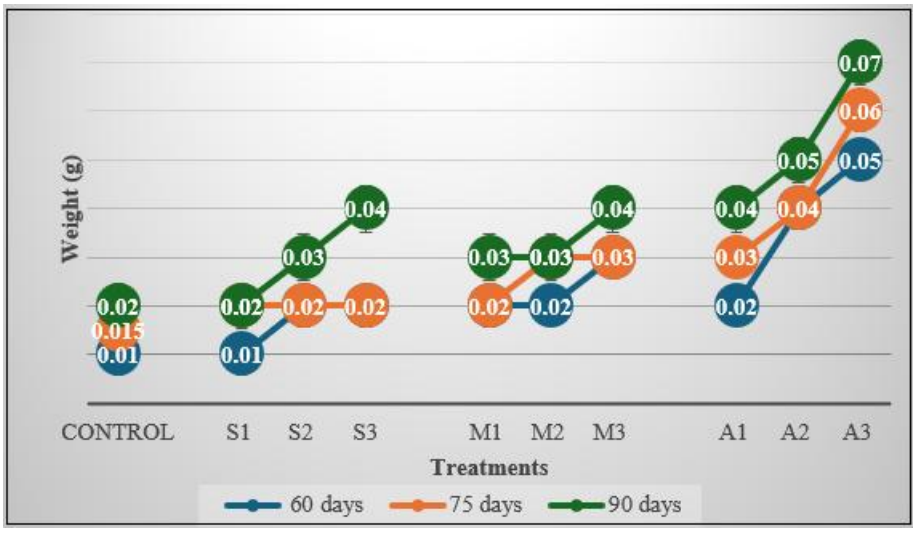

Figure 1: Weight gain (WG) of Neon tetra fed with different concentrations and durations of phytoextracts

The control fish group showed a mean body weight of 0.01 g at 60 days, *Spirulina* treatments S1 had 0.01g, while S2 and S3 attained 0.02 g. *Moringa* treatments M1 and M2 showed 0.02g, while M3 recorded 0.03 g. Further Ashwagandha treatments yielded 0.02 g, while A1 and A2 yielded 0.04 g, and A3 showed a marked increase to 0.05 g.

After 75 days of treatment, the mean weight increased across all treatments, with the control reaching 0.015 g, and

Spirulina groups S1, S2, and S3 showed 0.02 g. *Moringa* treatments M1(0.02 g), while M2, and M3 reached 0.03 g. Ashwagandha showed gains with A1 (0.03 g) and A2 (0.04 g), and A3 peaking at 0.06 g.

By 90 days, the control treatments attained 0.02 g, while the *Spirulina* groups S1 reached 0.02g, S2 reached 0.03 g, and S3 reached 0.04 g. The *Moringa* group showed intermediate values of 0.03 g for M1 and M2, and 0.04 g for M3. Ashwagandha group A1 increased to 0.04 g, A2 to 0.05 g, and A3 showed the highest mean weight of 0.07g.

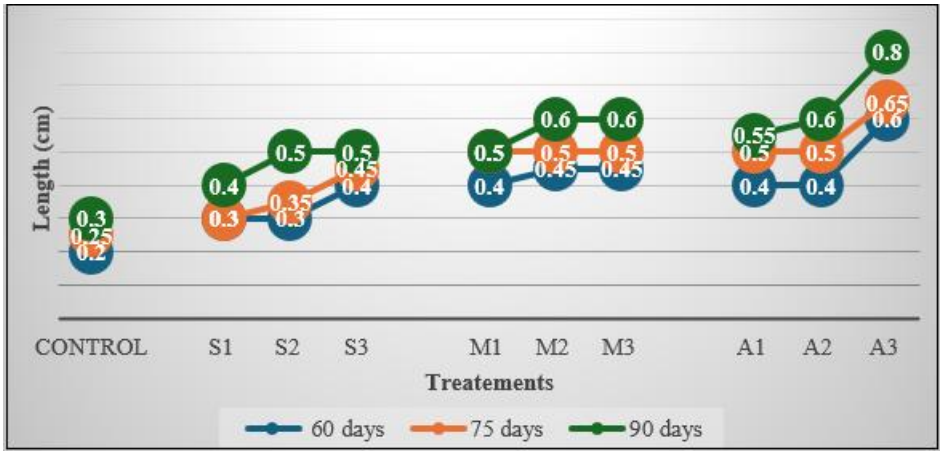

Figure 2: Length gain of Neon tetra fed with different concentrations and durations of phytoextracts

The control fish group showed a length gain of 0.2 cm at 60 days, *Spirulina* treatments S1 showed 0.3 cm, S2 (0.35 cm), and S3 (0.4 cm). *Moringa* groups M1 (0.4 cm), M2, and M3 showed 0.45 cm. Ashwagandha diets A1 and A2 gained 0.4 cm, while A3 showed a marked increase to 0.6 cm. After 75 days of treatment, the mean length increased across all treatments, with the control reaching 0.25 cm, and *Spirulina* groups S1 (0.3 cm), S2 (0.35 cm) and S3 showed 0.45 cm. *Moringa* treatments M1, M2 and M3 gained 0.5 cm. Ashwagandha showed gains with A1 and A2 gained 0.5 cm and A3 peaking at 0.65 cm. By 90 days, the control treatment attained 0.3 cm, while the *Spirulina* groups S1 reached 0.4 cm, S2 and S3 reached 0.5 cm. *Moringa* fed fish showed values of 0.5 cm for M1, M2 and M3 showed 0.6 cm. Ashwagandha treatments A1 increased to 0.55 cm, A2 to 0.6 cm and A3 shows the highest mean length of 0.8 cm.

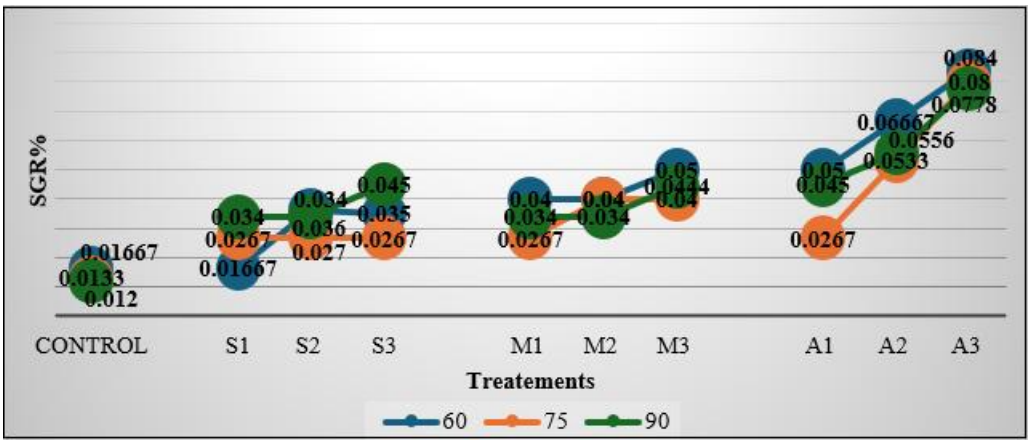

Figure 3: Specific Growth Rate (SGR%) of Neon tetra for the experimental duration

Specific Growth Rate (SGR%) of neon tetra increased with all phytoextract diets compared with the control at all sampling times, with clear numerical differences among treatments. At 60 days, SGR rose from 0.011 in the control treatment to 0.017, 0.034, and 0.035 in S1, S2, and S3, respectively; 0.045 and 0.066 in A1 and A2; and peaked at 0.084 in A3, then decreased to 0.034, 0.04, and 0.05 in M1, M2, and M3. At 75 days, SGR values ranged from 0.013 (control) to 0.027 (S1–S3 and A1), 0.058 (A2), 0.088 (A3), 0.027 (M1), 0.04 (M2), and 0.04 (M3), again showing the highest growth rate in A3.

By 90 days, SGR was 0.013 in the control, 0.034 in S1, 0.036 in S2, 0.045 in S3, 0.045 in A1, 0.055 in A2, and 0.078 in A3, while M1, M2, and M3 showed 0.034, 0.044, and 0.054, respectively. Across all periods, the diet containing 1.00% Ashwagandha (A3) consistently produced the highest SGR values (0.084, 0.088, and 0.078 at 60, 75, and 90 days), indicating superior growth efficiency relative to *Spirulina*, lower Ashwagandha levels, *Moringa* treatments, and the control.

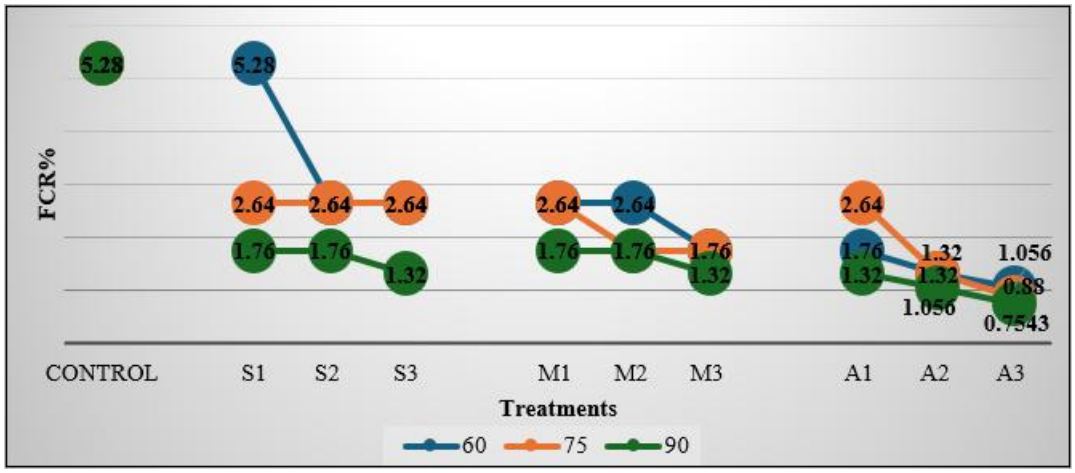

Figure 4: Food Conversion Ratio (FCR%) of Neon tetra for the experimental duration

Feed conversion ratio (FCR%) decreased markedly in all phytoextract-supplemented groups compared with the control at 60, 75, and 90 days. At 60 days, FCR dropped from 5.28 in the control treatment to 2.64 in S1–S3 and A1, 1.32 in A2, 1.05 in A3, 2.64 in M1–M2, and 1.76 in M3. At 75 days, FCR declined further from 5.28 (control) to 2.64 (S1 - S3 and A1), 1.32 (A2), 1.05 (A3), 2.64 (M1 - M2), and 1.76 (M3).

By 90 days, the most efficient feed utilization was observed, with FCR falling from 5.28 in the control treatment to 1.76 in S1 - S2, 1.32 in S3 and A1, 1.05 in A2, and the lowest value of 0.9843 in A3; M1, M2, and M3 showed intermediate FCRs of 1.76, 1.76, and 1.32, respectively.

4. Discussion

The success of aquaculture relies on several critical factors, among which an appropriate and balanced diet is paramount for ensuring optimal growth and health of fish [11]. The present findings demonstrate that dietary supplementation with phytoextracts significantly enhances the physiological condition of Neon tetra. Tacon [12] reported that *Spirulina* supplementation enhanced growth, as its carotenoid content positively influences metabolic activity in fish. The present study coincides with the above author.

Abdel-Latif [1] reported that *Moringa* extract improved weight gain, length increment, feed conversion ratio (FCR), and specific growth rate (SGR) in ornamental fish, likely due to its richness in essential nutrients such as proteins, vitamins, and minerals that contribute to a balanced diet. The present study revealed that an increase in growth performance occurred with increased concentration and duration. This may be related to the presence of chemical composition in dried *Moringa* leaf powder. Those compounds may positively affect the physiological growth and functions, resulting in improved Fish growth performance in neon tetra.

Ashwagandha, being a powerful anti-oxidant's acts as a strong anti-stress agent. The positive influence of ashwagandha on growth performance and feeding efficiency of fish has been reported in various fish species. Chatterjee [3] reported that the compounds in Ashwagandha may promote appetite stimulation, boost immunity, and support efficient protein utilization. Results of the present study observed an increased growth performance at various concentrations and durations can be attributed to the presence of organic compounds in Ashwagandha treatment.

The SGR and FCR patterns confirm that growth enhancement was closely associated with improved feed utilization rather than increased feed intake alone. SGR in the A3 group was consistently highest at varied concentrations and time intervals, whereas other treatments showed decreased levels of SGR values. FCR values declined markedly with phytoextract supplementation compared to control.

The present study highlights the potential of Ashwagandha, *Moringa*, and *Spirulina* phytoextracts as natural growth promoters in ornamental fish nutrition, with Ashwagandha at 1.00% inclusion showing particular promise. For commercial neon tetra culture, such supplementation could shorten production cycles, improve feed efficiency, and enhance profitability, while meeting the growing demand for plant-based, eco-friendly additives in aquafeeds.

5. Conclusion

The study establishes that the addition of phytoextract in commercial feed at different concentrations gives a positive impact. Ashwagandha concentration significantly enhances the growth performances of Neon tetra compared *to Moringa* and *Spirulina*. Protein-enriched formulations contribute to better growth performance, but sustainable feed design must consider nutrient balance, digestibility, and long-term vitality.

Acknowledgement
The authors are grateful to the Department of Zoology, Bangalore University, for providing continuous support and lab facilities during the course of study.

Conflict of interest
The authors declare no conflict of interest.

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