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GROWTH PERFORMANCE OF ANGELFISH, *PTEROPHYLLUM SCALARE* FED WITH DIFFERENT LIVE WORM DIETS

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Abstract: Diet forms the major input and one among the factors that controls growth of any organism under controlled conditions. Feeding the young ones with live feeds are essential for better growth and coloration. An experiment was set up to record the effect of differenent worm diets in the growth of Angel fish (*Pterophyllum scalare*), a most accepted species of ornamental fish globally. Growth in terms of morphometric measurements was assessed for angel fishes grown in aquarium glass tanks of standard size fed different worm diet ingredients. Tubifex worms, vermicompost worms, bloodworms and formulated feed as control were administered for experimental fishes for a period of 90 days and growth in terms of total length, standard length(cm) and weight(gm) were assessed in 30 days interval. Analysis of variance (One Way ANOVA) showed vermicompost worm group performed significantly ($P<0.001$) well in growth of angelfish and regression analysis resulted a good relationship between growth and the period of growth for all treatments.

Keywords: Worm Diet, tubifex, bloodworm, vermicompost worm, growth, aquarium, Angel fish.

INTRODUCTION

Aquarium fish trade is a rapidly growing global industry (Andrews, 1992) and it forms livelihood of many people in many countries including India (Anon, 2011). A significant factor that governs any aquaculture venture including ornamental fish trade is its nutrition and food, among which natural and/ or live foods are likely to stimulate feeding response and natural growth (Dey, 1996). Natural foods are not offered or practiced in large scale commercial units due to lack of bulk availability, non-production of commercial live food and even if such live foods are available, it will be high priced like that of *Artemia*, which results in non-profitability of the unit. A lot of researches are progressing to find out the judicious usage of locally available natural live feeds especially in the form of live animals/plants/single cell protein without causing much destruction to the biodiversity.

Among aquarium fishes, angel fish is a good old and most preferred fish by aquarium hobbyists and a lot of studies have been reported on various aspects including its nutrition, biology and growth (Schultz, 1967; Blom and Dabrowski, 2000; Gracia-Ulloa and Gomez Romero, 2005; Cacho, 2006; Rodrigues and Fernandes, 2006; Ortega-Salas *et al*., 2009; Amin Farahi *et al*., 2010; Ali *et al*., 2016; Eagderi *et al*., 2017). The social isolation, aggression and behaviour of angelfish were described by Gomez-Laplaza (1993). Although angel fish accepts artificial diets, it results in poor performance, especially in growth, colouration and survival rates (Ali *et al*., 2016). Recently Espitia-Manrique *et al*. (2017) reported the growth and body composition of angel fish. Several experimental trials are conducted to find out the efficacy of different protein and vitamin diet to angel fish (Blom and Dabrowski, 2000; Rodriguez and Fernandez, 2006). Effect of feeding frequency on growth, survival rate and reproductive performance of angel fish was reported by Kasiri *et al*. (2011; 2012). Ali *et al*. (2016) reported impact of formulated feed with different protein sources on growth and survival of angel fish. Nekoubin *et al.* (2012) studied the effect of symbiotic materials on growth, survival and reproduction of angel fish. Gad Degani and Yehuda (1996) reported effect of different plant/ animal origin diets, artemia diet and mosquito larvae diet on reproduction of angel fish. Effect of different feed types including Daphnia diet was tested in angel fish by Bahadir *et al.* (2009). Even though there were studies on nutrition and growth, live feed effect on growth of angel fish was not yet reported. The present study was undertaken to evaluate different type of live worm diets to the growth performance of ornamental fish, *Pterophyllum scalare*.

MATERIALS AND METHODS

Experimental Fish

The angelfish *Pterophyllum scalare* (family Cichlidae) was selected for the study due to its adaptability, acceptance of wide food spectrum, its economic, ornamental value and availability. 10-15 day old, healthy, uniform sized (0.94±0.21cm; 0.85±0.24 mg) and disease/parasite free fishes were collectd from the local aquarists and transported to the wet laboratory without much distarbance in oxygen filled bags.

Experimental Diet

Diverse and variety of natural and live feed materials were selected, which were locally available. Tubifex worms (*Tubifex tubifex*), vermicompost worm (*Eudrillus eugeniae*) and blood worms (*Chironomus clacalis*) were selected as experimental diet along with formulated research feed as control diet. The crude proximate composition of different diet compiled from secondary data is provided in Table 1. Formulated feed was prepared at laboratory by steam cooking the dough by mixing required quantities of rice flour, groundnut oil cake, tapioca powder and rice bran to form about 30% standard protien pelleted feed.

Experimental Setup

After acclimatization to the laboratory conditions, fishes were transferred to experimental glass tanks (60×30×30cm) with 30L water capacity filled with de-chlorinated water. 10 pre-measured (total and standard length: cm and weight: mg) angel fishes were introduced in to each experimental tank including control tank. The fishes were fed at 5% of its total pooled body weight with respective feed and the unfed along with faeces if any was removed after two hours of feeding at morning and evening. The experiment was continued for 90 days, during which length (total: TL and standard: SL; cm) and wet body weight (Wt; gm) measurements were recorded at every 30th day using a digital caliper and electronic balance respectively with 0.001 accuracy. 25% of the water was replaced/exchanged per week for all tanks and the entire experimental system was run in triplicate.

Statistical Analyses

Data from the experiment was entered into a personal computer and expressed in terms of mean and standard deviation (±SD) and statistical analyses were done using 'R' software. Length and weight measurements per 30 day till termination of the experiment for different treatment were compared using Analysis of variance (Two Way ANOVA). Similarly the growth per month for each treatment was also analyzed with ANOVA and post-hoc comparisons using Duncan's Multiple Range (DMR) test to identify the best treatment (Zar, 1984). The growth in terms of total length and weight of angel fish was expressed as a regression model against days of observation after natural logarithmic (*ln*) transformation.

Table 1. Crude proximate composition (%) of experimental diets

Experimental Feed	Crude Protein (%)	Fat (%)	Ash (%)	Crude Fibre (%)	Moisture (%)
Tubifex worm	42.80	5.11	7.79	3.04	41.55
Vermicompost worm	42.20	7.71	10.23	2.56	38.18
Blood worm	41.80	9.72	12.34	2.90	34.00
Formulated Feed	36.00	4.41	3.10	3.00	56.36

RESULTS

Growth response of *P. scalare* to different natural worm diets along with a control formulated feed was recorded in every 30th day up to 90 day and growth was assessed in terms of total length (TL), standard length (SL) and weight (Wt). The data obtained were statistically tested for its treatment and observation period difference and the results are presented in tables and graphs.

Length

Total length (cm) of the fishes statistically treated to compare between treatment and between days of observation for growth increment and the results are given in table 2. At 0 day of observation all treatments were similar without significant difference (P>0.05) between treatments. But all other days of observation showed significant difference between treatments with high degree of significance with maximum difference at 90 day of observation. Maximum total length was registered at termination of experiment in Tubifex treatment (2.30 ± 0.38) followed by control treatment. Total lengths in vermicompost worms and bloodworm treatments were not performed well compared to control treatment and least growth was registered in blood worm group. All treatment showed significant difference between days of observation including the control treatment. The percentage increment in total length with respect to control treatment is given in figure 1.

Standard length (cm) of the fishes were also measured at 30 day interval and statistically treated to compare between treatment and between days of observation for growth increment and the results are given in table 3. Similar to total length, standard length at 0 day of observation of all treatments were similar without significant difference between treatments. But all other days of observation showed significant difference between treatments with high degree of significance with maximum difference at 90 day of observation. Maximum standard length was registered at termination of experiment in Tubifex treatment (2.06 ± 0.40) followed by control treatment. Total length in vermicompost and blood worm treatment were registered poor standard length increment than control treatment and blood worm group showed least standard length growth among the tested ones. All treatment showed significant difference between days of observation including the control treatment. The percentage increment in standard length with respect to control treatment is given in figure 2.

Weight

Weight of the fishes were also measured at 30 day interval and statistically analysed to compare between treatments and between days of observation for growth increment and the results are given in table 4. Weight at 0 day of observation of all treatments was similar without significant difference between treatments. But all other days of observation showed significant difference between treatments with high degree of significance with maximum difference at 90 day of observation. Maximum weight was registered at termination of experiment in Tubifex treatment (2.46 ± 0.56) followed by formulated feed (control) treatment. Weight in bloodworm treatment was registered least weight increment and comparable with vermicompost worm treatment. All treatment showed significant difference between days

Table 2. Analysis of variance (Two Way ANOVA) of total length (cm) of angelfish comparing different diet treatments and days of observation

Observation	Control		Tubifex Worm		Blood Worm		Vermicompost Worm		F value
	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD	
0 Day	0.94^{a}	0.21	0.94^{a}	0.23	0.92^{a}	0.35	0.95^{a}	0.25	1.778
30 Day	1.29^{a}	0.15	1.25^{a}	0.17	1.28^{a}	0.3	1.47^{b}	0.19	8.056**
60 Day	1.72^{ab}	0.29	2.13^{c}	0.42	1.56^{a}	0.44	1.77^{b}	0.19	55.507***
90 Day	2.01^{b}	0.3	2.30^{bc}	0.38	1.85^{a}	0.41	1.98^{ab}	0.21	254.013***
F value	28.182***		573.913***		6.283**		2.235*		

* P < 0.05; ** P < 0.01; *** P < 0.001; a, b, c: Means with same superscript within each row do not differ each other (DMR Test)

Table 3. Analysis of variance (Two Way ANOVA) of standard length (cm) of angelfish comparing different diet treatments and days of observation

Observation	Control		Tubifex Worm		Blood Worm		Vermicompost Worm		F value
	Mean	+ SD	Mean	+ SD	Mean	+ SD	Mean	+ SD	
0 Day	0.61^{a}	0.23	0.55^{a}	0.2	0.69^{a}	0.41	0.64^{a}	0.29	1.045
30 Day	1.05^{a}	0.15	1.09^{b}	0.22	0.95^{d}	0.39	1.06^{b}	0.23	8.699**
60 Day	1.27^{b}	0.3	1.58^{bc}	0.46	1.02^{b}	0.46	1.43^{b}	0.2	56.362***
90 Day	1.70^{b}	0.32	2.06^{d}	0.4	1.55^{c}	0.46	1.67^{ab}	0.22	242.781***
F value	71.582***		695.373***		7.209**		27.233***		

* P < 0.05; ** P < 0.01; *** P < 0.001; a, b, c, d, e: Means with same superscript within each row do not differ each other (DMR Test)

Table 4. Analysis of variance (Two Way ANOVA) of weight (gm) of angelfish comparing different diet treatments and days of observation

Observation	Control		Tubifex Worm		Blood Worm		Vermicompost Worm		F value
	Mean	+ SD	Mean	+ SD	Mean	+ SD	Mean	+ SD	
0 Day	0.85^{a}	0.24	0.99^{ab}	0.25	0.94^{a}	0.27	0.78^{a}	0.11	1.761
30 Day	1.05^{a}	0.36	1.27^{b}	0.29	1.01^{a}	0.26	1.06^{b}	0.14	9.904**
60 Day	1.34^{b}	0.31	1.75^{c}	0.24	1.11^{ab}	0.28	1.37^{c}	0.24	13.302**
90 Day	1.83^{b}	0.43	2.46^{d}	0.56	1.42^{b}	0.52	1.79^{d}	0.35	32.076***
F value	35.930***		92.845***		2.973*		23.673***		

* P < 0.05; ** P < 0.01; *** P < 0.001; a, b, c, d: Means with same superscript within each row do not differ each other (DMR Test)

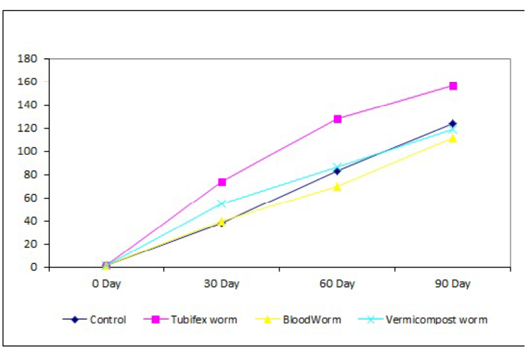

Fig. 1. Percentage increment in total length of Angel fish fed different worm diets

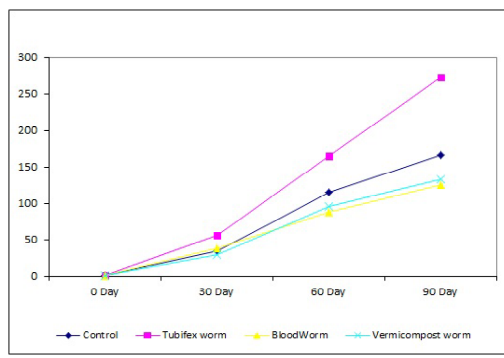

Fig. 2. Percentage increment in standard length of Angel fish fed different worm diets

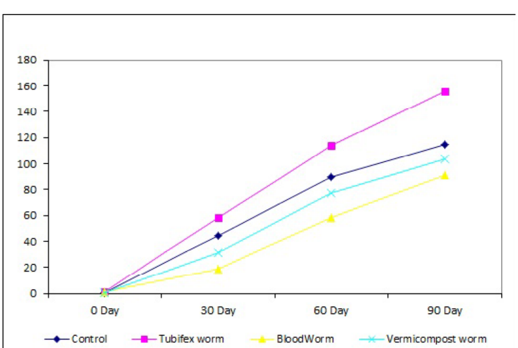

Fig. 3. Percentage increment in weight of Angel fish fed different worm diets

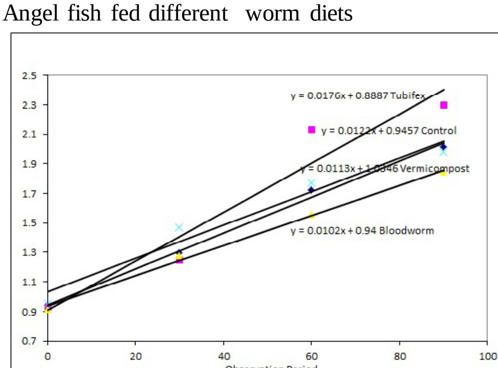

Fig. 4. Regression between total length and growth period of angel fish in different treatments

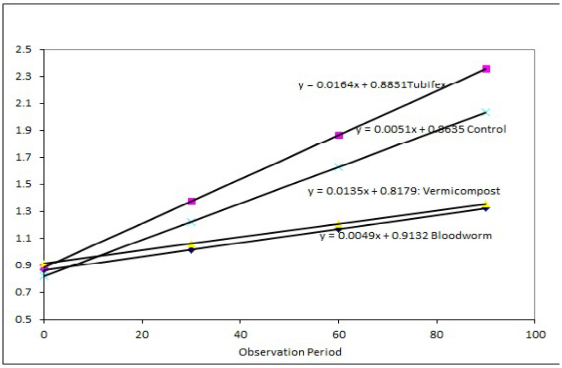

Fig. 5. Regression between weight and growth period of angel fish in different treatments

of observation including the control treatment. The percentage increment in total length with respect to control treatment is given in figure 3.

Regression Analysis

Regression analysis was employed to model the relationship between length and weight increment with days of observation. Regression analysis was performed on total length and weight against days of observation for each treatment separately as each treatment has shown individual growth performance. Tubifex group showed significantly good relationship with high slope value for day-weight relationship, which was followed by control group. Bloodworm group showed least b values in regression analysis. With respect to day-total length relationship, again tubifex group showed significant 'b' value but the least values were registered for bloodworm group. The control group showed better growth with respect to total length than other few groups. All the groups showed good growth pattern in laboratory conditions in response to different feeding diets. The regression graphs and regression equations for total length and weight are given in figures 4 and 5 respectively.

DISCUSSION

In this study three diverse natural live worm feeds has been tested such as tubifex worms, vermicompost worm and bloodworms for their growth response of *P. scalare*, the angel fish along with control formulated research diet with 30% protein. Previous studies for many of these feeds were not reported except few like tubifex and formulated diet. All feeds under trial gave good growth response in terms of weight gain except blood worms and vermicompost worm diets . Tubifex treatment resulted maximum (P<0.001) growth followed by control treatment than other worm treatment under trial. Since water quality parameters (pH 7.2 - 7.8; Temperature 27.0±1.0°C and Dissolved oxygen > 4.0 mg/L) were stable and optimum for the angel fish (Axelrod *et al*., 1997) maintained throughout the experiment, and diets were given at same daily ration and readily consumed by fish, it is suggested that overall results in this study were influenced mainly by the nutritional quality of the tested diets only. The nutritional value of one food for a species is related to the degree of correspondence between biochemical composition and nutritional requirements of that species, hence some growth parameters like length showed better increment in control diet than the feeds under trial. Several studies reported growth and biological performance of angel fish fed formulated diet. Schultz (1967) reported the growth and reproductive performance by different feeds in freshwater angelfish (*Pterophyllum scalare*). Effect of different feed types on growth and feed conversion ratio of angel fish was reported by Bahadir *et al*. (2009). Gad Degani and Yehuda (1996) tested mosquito larvae, turkey heart meal and soybean based protein diet on reproduction and larval rearing of angel fish and reported mosquito larvae and turkey heart diets resulted better performance on reproduction. A comprehensive report on dietary protein and energy requirement of juvenile angel fish was reported by Zuanon *et al.* (2009). Nekoubin *et al.* (2012) reported effects of symbiotic material on growth performance, survival and reproduction of angel fish and reported the superior effect of symbiotic material, Biomar on growth and reproduction in angelfish. Ali *et al*., (2016) reported impact of formulated diets on the growth and survival of angel fish. Recently, effect of feeding frequency on growth performance and survival ratio was reported in angelfish by Kasiri *et al*. (2011) and recommended that four meals per day and two meals per day gave best results and conversion efficiency ratio. Hence in the present study, different diets were offered two times per day, which might be optimum for growth in controlled conditions.

Tubifex worms form excellent food for wild as well as cultured fish species, which is a locally available fish feed ingredient. The advantages of *tubifex* in the diet of ornamental fish have been demonstrated by several authors (Amin Farahi *et al*, 2010; Kasiri *et al.*, 2011). The present study supports with the results obtained in fantail guppy and other ornamental species. The latest studies showed that live feeds have various effects on growth performance of fish. In the present study also, tubifex diet registered first position in growth performance of angel fish. Kasiri *et al.* (2011) studied effect of three natural feeds such as Tubifex, earthworm and Gammarus on reproductive behavior of Angel fish including growth and survival. Vermicompost worms are highly nutritious feed for the fishes. In the present study, vermicompost worm showed significant low growth rate ($P < 0.05$) than control diet. Moreover, vermicompost worm diet resulted in poor length increment in angel fishes. This may be due to poor digestibility of vermicompost worm by fishes caused by thick cutaneous as well as mucilaginous covering of the worms. Amin Farahi *et al.* (2010) reported similar results in *P. scalare*. Earthworm diets resulted poor growth performance than commercial extruder diet. But better survival and larval characteristics were obtained, when administered with earthworm mixed with extruder diet. Effect of earthworm diets were also reported in other fish species by Stafford and Tacon (1988) and Kruger *et al*. (2001). Blood worms showed the poorest growth among the tested diets, which also may be due to poor digestibility of fishes and thick mucilaginous covering of blood worms. More studies are warranted for growth performance of different species of fishes using blood worms as blood worms forms a good live feed, which are easy to collect and culture.

The growth pattern of angelfish in natural conditions and early developmental stages are modeled by Eagderi *et al*. (2017). The growth pattern explained by regression model between weight with days of observation in each treatment were supporting the grwoth pattern in each treatment and a good linear relationship with high slope (b) value was obtained for tubifex treatment followed by control treatment. Since as suggested by Eagderi *et al*. (2017), *P. scalare* follows an extreme allometric pattern, length-day relationship may not hold good in all conditions which again proved by this study, as poor relationships with low 'b' values were obtained for length-day regression analysis.

Out of four feeds tested, highly significant growth rate ($P < 0.001$) was registered in fish fed with tubifex worm diet and other groups like vermicompost worm and blood worm diets registered poor growth performance than control diet with 30% protein. Considering economic viability and ease of availability, tubifex can be recommended for feeding of angel fish in mass production centers for its production, grow-out and growth performance. In addition to its growth promoting properties, tubifex can be cultured easily in lab condition and its mass culture is possible. Collection of tubifex can be done from running water bodies especially in urban and rural channels or rivulets throughout the year without much expenditure. Its collection and or culture generates another employment opportunity as live feed production centers, which again can be regarded as a cottage industry especially for women empowerment along villages that practice ornamental fish culture.

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