



Studies on the Growth Responses of Common Carp (*Cyprinus carpio*) Progenies Raised Using Different Starter Diets

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

200 fry of carp obtained from induced breeding by stripping were fed three times daily ad libitum with Artemia (DT1), commercial starter diet (DT2), and dried egg yolk (DT3) for 8 weeks. Each treatment was in triplicates in indoor hatchery. At the end of the experiment, the progenies mean weight gained (MWG) was highest in the treatments fed Artemia (3.490 ± 0.015^a) as compared to others with significant difference ($P < 0.05$). Mean weight gained (MWG) was highest in the treatments fed Artemia. Percentage weight gain (%WG) and specific growth rate (SGR) had no significant differences ($P < 0.05$). Feed conversion ratio (FCR) was highest ($P < 0.05$) in treatment fed with smashed egg yolk. Feed conversion efficiency (FCE) was highest ($P < 0.05$) in the treatment fed with composed feed. Mortality rate was highest in treatment fed with Artemia, and percentage survival was highest ($P < 0.05$) in treatment fed with composed feed. Percentage jumpers per treatment were highest in Artemia diet. In conclusion, it is imperative that Artemia feed (amidst other starter diets researched on) is most preferable for the optimum growth and development of common carp fry.

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1. INTRODUCTION

Aquaculture is the fastest growing sector of animal production worldwide, growing more rapidly than all other animal food production sectors [1]. It is worthy of note that in aquaculture worldwide, the most important fish species used in fish farming are, in the order Common Carp, Salmon, Tilapia, and Catfish [2]. In the last 25 years, aquaculture production grew by up to 8.5% annually [2], and currently covers roughly half the global demand for fish products for human consumption [3]. Annually, almost 100 million tons of fish are captured from the ocean globally, of which around 70 million tons are intended for direct human consumption. This amount includes hundreds of species, some of which are threatened with extinction [4] and [5].

Globally, aquaculture is the surest way of conserving ocean and water resources, and facilitating sustainability of fish and water resources, since its practice will reduce overexploitation of fish species through capture fisheries. Common Carp (one of the most important fish species in aquaculture) has not been significantly cultured in West Africa and especially in Nigeria's aquaculture system. A good example of a fish species currently going extinct in Nigeria's inland waters and aquaculture system is Common Carp fish, and no genuine reason for this has been stated other than the fact that it has not been given the necessary attention.

The constantly increasing demand for fish and fish products for human consumption must be covered by fish farming of different relevant fish species through aquaculture [6]. It implies some form of intervention such as regular stocking, proper management and very importantly, adequate feeding of the stock during the rearing process. These must be put in place to enhance commercial production of aquaculture. Hence, the importance of artificial feeding [7]. It promotes faster growth, allows higher stocking density, shorter cultivation periods and high survival of fish seed. Fry management especially fry nutrition is crucial to high seed development.

The cost of commercial Artemia in the local market today is no longer within the reach of the common fish farmer. Also, the nutritional requirements and handling of fish fry is complex and indeed tasking. Consequently, it has become

imperative to come up with a near substitute for commercial Artemia to guarantee sustainable aquaculture. Chicken egg yolk has been reported to be rich in vital nutrients for fish development. This study is designed to study growth responses of progenies of *Cyprinus carpio* using Artemia, 0.2mm-2mm commercial starter diets and smashed chicken egg yolk in a feeding trial.

1.1 Study Area

This study was carried out in Panyam fish farm, Panyam, Mangu Local Government Area of Plateau State, Nigeria. Panyam fish farm has existed since 1954 and is well known specifically for Carp fish farming in West Africa. It is situated in Mangu, around 60 kilometers South-East of Jos. The physico-chemical parameters of experimental water were taken three times in a day at 7am, 12noon and 6pm respectively, using relevant instruments and was observed to be within tolerable range for Carp fish aquaculture as described by Bert, Billard and Sawyer *et. al* [8,9,10].

2. MATERIALS AND METHODS

33 *Cyprinus carpio* broodfish (12 females and 21 males) were selected (based on physically observable characters after little pressure was applied on the abdominal regions towards the genital area of each broodstock, to check quality of milt and eggs) and obtained from Panyam Fish Farm. The selected male and female fish were isolated in separate hapa net of 3m by 7m by 1.5m dimension each and fed intensively with 9mm size of vital feed extruded floating pellets, for 3 months, before they were certified ready for spawning, and used for this experiment. Breeding activities was carried out in the hatchery, and its progenies were used for this experiment.

2.1 Feeding Trial

Two hundred (200) fry of the Carp fish hatched was counted and isolated in three replicates for each treatment from the progenies gotten of the induced stripping in concrete tanks. The three replicates were for each of the three treatments of artemia as treatment one (T1), 0.2 commercial diet as treatment two (T2), and egg yolk as treatment three (T3). The hatchlings were fed the three starter diets 3 times daily at 9:00am,

2:00pm and 6:00pm for a period of 8 weeks (56days).

The diets fed were industrially produced artemia fed by dispersed sprinkling; 0.2mm-2mm commercial starter diets fed by dispersed sprinkling; and smashed chicken egg yolk, cooked hard at 100°C for about 10 minutes, de-shelled, yolk isolated and smashed, which was then administered in drops per sectional area in the concrete ponds.

The weight of fish was taken using a sensitive weighing balance and the length was measured by a measuring Rule. Hatchlings were monitored for eight weeks. To maintain good hygiene, reduce fish stress and water pollution, egg remnant, as well as crippled and dead larvae were removed by siphoning. This practice was done daily.

Survival of fry and mortality rate were recorded from each sample. Equal amount of the three different feeds were measured and administered at the feeding time, 3 times daily throughout the experiment. All hatchlings of treatment one were fed artemia. Hatchlings of treatment two were fed commercial feed and the hatchlings of the third treatment were fed smashed egg yolk at feeding time. At the seventh day of every week, samples from the various treatments were collected and assessed morphometrically to obtain and subsequently record weight and length parameters the end of the 56 days of feeding.

From the records, growth parameters such as food conversion ratio (FCR), food conversion efficiency (FCE), specific growth rate (SGR), mean initial weight (MIW), mean final weight (MFW), mean weight gain (MWG) and survival rate were evaluated using appropriate mathematical formulas:

2.2 Food Conversion Ratio

This is the amount of feed fed as related to the growth of the fry.

$$FCR = \frac{\text{Weight gain}}{\text{Feed consumed}}$$

2.3 Food Conversion Efficiency

This is the percentage representation of the ability of the fish to convert the feed eaten to body flesh or weight.

$$FCE = \frac{\text{Feed Consumed}}{\text{Weight of fish}} \times 100\%$$

2.4 Specific Growth Rate

$$SGR = \frac{\text{Loge } W_2 - \text{Loge } W_1}{T} \times 100$$

Where:

- W₂ = Final weight
- W₁ = Initial weight
- T = Number of days of experiment

2.5 Survival Rate

This was the difference between the initial and final sample size.

- N₀ = Total number of fry at fingerling
- N_e = Total number of fry at end of experiment

Growth of fry was measured weekly by taking weight and length. Fry were collected randomly and placed on filter paper to absorb water. The fry were then transferred to a small bowl containing water on a digital weighing balance.

2.5.1 Mean Initial Weight

Fry were counted and weighed. The weight obtained were divided by number of the fry

$$M.InW = \frac{N_w}{N}$$

Where M.InW is in grams (g)

- N = Number of fry
- W = weight of fry

2.6 Mean Final Weight

The surviving fingerlings were counted and weighed. The weight obtained was divided by the number of the surviving fingerlings to obtain the mean final weight.

$$M.FnW = \frac{(N_{sf} \times W) + N_{sf}}{N_{sf}}$$

Where:

- M.FnW = Mean final weight
- N_{sf} = Number of surviving fingerlings
- W = Weight of fingerlings

2.7 Mean Weight Gained

This is the difference between the mean final weight and mean initial weight.

2.8 Data Analysis

Data were analyzed using Excel Stat and Minitab 14 to highlight the possible heterogeneity between the populations.

3. RESULTS

The result of percentage weight gained (%WG), specific growth rate (SGR), feed conversion ratio (FCR), Feed conversion efficiency (FCE), percentage mortality, and percentage survival at the end of the eight weeks experiment of the fry to fingerlings stage of Carp Fish cultured in the indoor hatchery through purely artificial propagation, and fed with Artemia, commercially compounded feed starter diet, and smashed egg yolk showed different indications. Table 2 shows the for details, and graphical representations of length and weight growth progression on a weekly basis during the experiment in Fig. 1 and 2, with jumper records in Fig 3, obtained from Carp fry fed different starter diets.

Mean weight gained (MWG) was highest in the treatments fed artemia (3.490 ± 0.015^a) as compared between commercial starter feed (2.773 ± 0.003^b), and smashed egg yolk (2.566 ± 0.006^c), with a significant difference ($P < 0.05$).

Percentage weight gained (%WG) had no significant difference ($P < 0.05$) between the treatments fed Artemia (99.048 ± 0.119), Composed Feed (99.149 ± 0.159), and Smashed Egg Yolk (98.718 ± 0.256).

Mean weight gained (MWG) was highest in the treatments fed Artemia (3.490 ± 0.015^a) as compared between composed feed

(2.773 ± 0.003^b), and smashed egg yolk (2.566 ± 0.006^c), with a significant difference ($P < 0.05$).

Specific growth Rate (SGR) had no significant difference ($P < 0.05$) between the treatments fed artemia (0.083 ± 0.002), composed feed (0.085 ± 0.003), and smashed egg yolk (0.078 ± 0.004).

Feed conversion ratio (FCR) was highest in treatment fed with smashed egg yolk (0.032 ± 0.000^a), as compared to artemia (0.030 ± 0.000^b) and composed feed (0.024 ± 0.000^c), at significant difference ($P < 0.05$).

Feed conversion efficiency (FCE) was highest in treatment fed with composed feed (41.548 ± 0.182^a), as compared to Artemia (33.016 ± 0.39^b), and smashed egg yolk (30.556 ± 0.079^c), at significant difference ($P < 0.05$).

Percentage mortality was highest in treatment fed with artemia (4.133 ± 0.467^a), as compared to composed feed (1.100 ± 0.115^b), and smashed egg yolk (3.100 ± 0.603^b), at significant difference ($P < 0.05$).

Percentage survival was highest in treatment fed with composed feed (98.900 ± 0.115^a), as compared to smashed egg yolk (96.900 ± 0.603^b), and artemia (95.867 ± 0.467^b), at significant difference ($P < 0.05$).

Treatment fed with artemia was observed to have a relatively higher number of jumpers as compared with treatment fed with starter diets and smashed egg yolk.

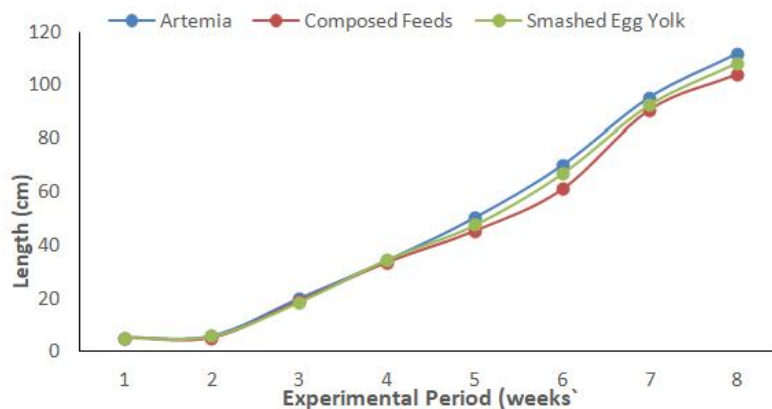


Fig. 1. Graph showing weekly Length Changes per dietary treatment

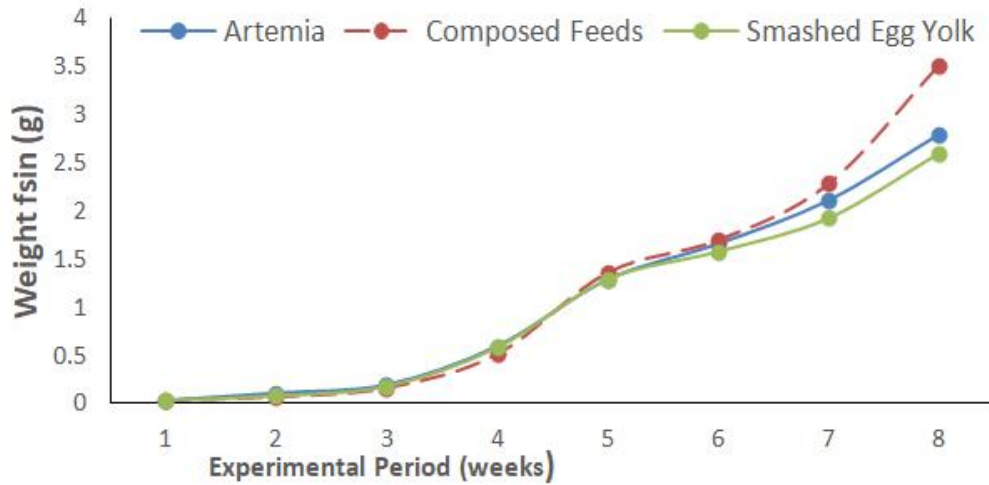


Fig. 2. Graph showing weekly Weight Changes per dietary treatments

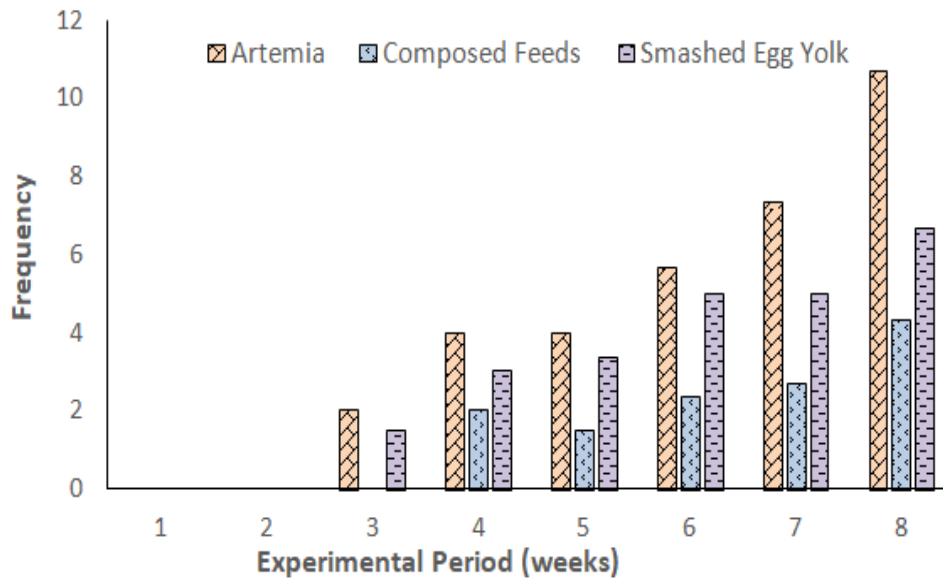


Fig. 3. Graph showing weekly Jumper records per dietary treatments

Table 1. Water Quality Parameters for Panyam Fish Farm Pond Water

Parameters	Time			
	7 am	12 noon	6 pm	Mean
Temperature (°C)	20.40±0.32	22.23±0.32	19.93±0.1	20.86±0.25
pH	7.48±0.05	7.60±0.11	7.55±0.08	7.54±0.05
Dissolved Oxygen (mg/L)	8.13±0.19	8.73±0.13	8.20±0.09	8.35±0.09
Total Dissolved Solids (mg/L)	133.67±2.84	140.77±2.58	135.88±2.22	136.77±1.54
Electrical Conductivity (µS/Cm)	237.21±2.90	240.18±3.55	230.28±1.65	235.89±1.78
Transparency (Cm)	42.33±0.64	57.13±0.68	42.37±0.64	47.28±1.49

Table 2. Growth Performance and Mortality of Carp fry fed different Starter Diets in indoor Concrete Tanks

Growth Performance Indices	Diet			P-Value
	DT1	DT2	DT3	
MIW (g)	0.026±0.003	0.030±0.005	0.033±0.006	-
MFW (g)	3.520±0.020 ^a	2.800±0.000 ^b	2.600±0.000 ^c	<0.010
MWG (g)	3.490±0.015 ^a	2.773±0.003 ^b	2.566±0.006 ^c	<0.010
%WG	99.048±0.119	99.149±0.159	98.718±0.256	0.307
SGR	0.083±0.002	0.085±0.003	0.078±0.004	0.386
FCR	0.024±0.000 ^c	0.030±0.000 ^b	0.032±0.000 ^a	<0.010
FCE	41.548±0.182 ^a	33.016±0.039 ^b	30.556±0.079 ^c	<0.010
% Mortality	4.133±0.467 ^a	1.100±0.115 ^c	3.100±0.603 ^b	0.008
% Survival	95.867±0.467 ^b	98.900±0.115 ^a	96.900±0.603 ^b	0.008
% Jumpers Per Treatment	15.17±0.01 ^a	5.50±0.00 ^c	11.50±0.00 ^b	

Means on the same row with different superscript are statistically significant ($p < 0.05$)

Table 3. Nutritional information of diets used for experiment

Feed Minerals And Vitamins	Diets		
	DT1	DT2	DT3
Crude Protein	51%	56%	15.86%
Crude Fat	14%	15%	26.54%
Crude Fiber	3.5%	0.3%	-
Crude Ash	8%	13%	-
Energy	-	-	3.59g
Phosphorous	1%	1.9%	390mg
Calcium	0.5%	3.1%	12mg
Sodium	1.6%	0.9%	-
Vitamin A	22000iu/kg	14000iu/kg	381mg
Vitamin B1	-	-	0.18mg
Vitamin B2	-	-	0.53mg
Vitamin B5	-	-	2.99mg
Vitamin B9	-	-	146g
Vitamin D3	1760iu/kg	1542iu/kg	218iu
Choline	-	-	820.2mg
Iron	-	78mg/kg	2.73mg
Iodine	-	6.6mg/kg	-
Manganese	-	26mg/kg	-
Zinc	-	78mg/kg	2.30mg
Potassium	-	-	109mg
Propyl gallate	-	100mg/kg	-
Butylated hydroxyanisole	66ppm	-	-
Butylated hydroxytoluene	60ppm	100mg/kg	-

Information source: Captured from body of feed container and wikipedia

DT1 = Artemia (Nutritional information retrieved from body of the feed container)

DT2 = Commercial Starter Diets (Nutritional information retrieved from body of the feed container)

DT3 = Smashed Dried Egg Yolk Per 100g (Nutritional information retrieved from Wikipedia)

4. DISCUSSION

Mean weight gained (MWG) was highest in the treatments fed artemia (3.490 ± 0.015^a) as compared between commercial starter feed (2.773 ± 0.003^b), and smashed egg yolk (2.566 ± 0.006^c), with a significant difference ($P < 0.05$). This was similar to the result obtained by Solomon et al. [11]. According to them, the fry responded better to decapsulated artemia cyst

(DAC) as highest weight gain (0.063 ± 0.001^a) was obtained in this diet as compared with dried quail egg (DQE) with (0.054 ± 0.001^b), coppens ctarter feed (CSF) with (0.054 ± 0.001^b) and on farm compounded Feed (OCF) with (0.051 ± 0.001^c) after 56 days. They also reported that the commercial diet used in their study even though contained highest crude protein of 53.39%, did not give the highest mean weight gain and specific growth rate. It is important not to forget that protein sources are the major contributors in aquaculture feed costs and fish meal is the preferred dietary protein source for many farmed fish and shrimp species because of its amino acid balance, vitamin content, palatability, and unidentified growth factors[12].

Commercial starter diets may be used in rearing fry with appreciable performance, but it is not the preferred diet of fish at the early stage of life [11]. In this experiment, the commercially compounded feed and Artemia diet were of similar food composition as that of Solomon et al. [11]. Also comparing the egg treatment, Solomon et al. [11] recorded the use of quail eggs, while in this study, chicken egg yolk was used. Imperatively, the lowest mean weight gain by the chicken egg yolk treatment may have been due to the low palatability of the diet as it was observed that the response of the fish to this meal was gradually reducing with time as the experiment progressed.

Percentage weight gained (%WG) had no significant difference ($P < 0.05$) between the treatments fed Artemia (99.048 ± 0.119), composed feed (99.149 ± 0.159), and smashed egg yolk (98.718 ± 0.256). The three treatments had fry gaining weight at seemingly even rate as they grew, though mean weight gain differed significantly with artemia taking the lead. The insignificant difference in percentage weight gained could be in association with the insignificant difference from their specific growth rate throughout the 56 days of observation.

Specific growth rate (SGR) too had no significant difference ($P < 0.05$) between the treatments fed artemia (0.083 ± 0.002), composed feed (0.085 ± 0.003), and smashed egg yolk (0.078 ± 0.004). This is slightly different from the result gotten and reported by Solomon *et al.*, [11], which had artemia (5.95 ± 0.02^a) significantly different ($P < 0.05$) from dried quail egg (5.69 ± 0.02^b), coppens starter feed (5.69 ± 0.02^b), and on-farm compounded feed (5.69 ± 0.02^b).

Though only artemia differed significantly as compared with the result gotten from my experiment, this implies that all the starter diets of both Artemia, commercially compounded starter feed, on-farm compounded feed, coppens starter feed, dried quail eggs, and smashed chicken egg yolk are justifiably utilized as feed by carp fry and fingerlings.

Mean final weight gained (MFW) had a significant difference ($P < 0.05$) between the treatments fed artemia (2.800 ± 0.000^b), composed feed (3.520 ± 0.020^a), and smashed egg yolk (2.600 ± 0.000^c). This indicates that the treatment fed with commercially composed feed weighed more than the treatment fed with artemia at the end of the experiment (at fingerling – juvenile stage), even though the treatment fed with artemia had a higher weight at fry stage. Since artemia had the highest mean weight gain and fastest growth rate at the initial feeding stage, the mean final weight may have consistently been higher most probably because the feed size had changed with the change in the mouth size of fish as they grew bigger. The change in feed size is generally accompanied with a difference in the percentage composition and mixture rate of feed ingredients and additives. The result obtained from my experiment is supported by the documentation from the work done and reported by Solomon et al. [11] which states that the growth pattern of fish changes according to the developmental stage of the fish. de-capsulated artemia cyst is the best for carp fry as a starter feed.

Feed conversion ratio (FCR) was highest in treatment fed with smashed egg yolk (0.032 ± 0.000^a), as compared to composed feed (0.030 ± 0.000^b), and artemia (0.024 ± 0.000^c), at a significant difference ($P < 0.05$). This shows that the smashed egg yolk was least utilized amongst the three feeds used for the three treatments, followed by the commercially formulated feed and then artemia. This agrees with the work done by Solomon et al. [11] which had artemia with least FCR amongst the other feed fed carp fry in the experiment they conducted. Also, according to Kim and Lee [13], de-capsulated artemia cyst is a better starter diet for carp. This is because its FCR value is the least and it is match with corresponding higher weight gain.

Feed conversion efficiency (FCE) was highest in treatment fed with artemia (41.548 ± 0.182^a), as compared to composed feed (33.016 ± 0.39^b), and

smashed egg yolk (30.556 ± 0.079^c), at significant difference ($P < 0.05$). This indicates that artemia was better utilized by carp fry in this experiment, followed by the commercially formulated feed (0.2 – 2mm), and then the egg yolk. This is not to say that any of the feed fed is bad, but in relativity to each other, the artemia did better. Comparing this result with that of Solomon et al. [11], though the other treatments apart from Artemia where of equal significant difference, as only de-capsulated artemia Cyst (109.30 ± 1.22^a) had a significant difference at ($P < 0.05$), as compared to dried quail Egg (90.10 ± 2.66^b), coppers starter feed (92.89 ± 2.01^b), and on farm compounded feed (92.80 ± 0.81^b).

Percentage mortality was highest in treatment fed with artemia (4.133 ± 0.467^a), as compared to smashed egg yolk (3.100 ± 0.603^b) and composed feed (1.100 ± 0.115^c), at significant difference ($P < 0.05$). However, according to Takeuchi et al. [14], with the poorly developed digestive system of carp fry, feeds must be formulated carefully to gain the maximum advantage of supplementary feeding. Therefore, the goal of feeding fry is not limited with growth enhancement but also includes another crucial aspect which is fry survival rate and its implication on the final productivity and profitability of the culture process. Result on mortality should have justified the documentation by Takeuchi et al. [14] if the treatment fed with the chicken egg yolk had a higher mortality, since it was not formulated. But the treatment fed with the industrially formulated artemia had more mortalities at a significant difference ($P < 0.05$), comparing with composed feed and chicken egg yolk. Interestingly, the mortality from treatment fed with the commercially composed feed had lowest mortality, inferring that it could have been better off than Artemia in terms of mortality. However, it is worthy of note that the higher mortality rate could have been due to water pollution which was observed to be faster in treatment fed with Artemia, even though the whole ponds were fed with water in a flow through system at even flow rates. Hence, Artemia fry feed has a higher tendency of water pollution.

Percentage Survival was highest in treatment fed with composed feed (98.900 ± 0.115^a), as compared to smashed egg yolk (96.900 ± 0.603^b), and Artemia (95.867 ± 0.467^b), at significant difference ($P < 0.05$). This is similar to the report from the work done by Basavaraja and Anthon [15] that documented a survival rate of 98% for

fry fed with conventional feed. However, like in the words of survival of Solomon et al. [11], fry inspite of high-quality starter feed must be married with appropriate management skill and handling.

5. CONCLUSION

Artificially produced feed (whether industrially, commercially, or locally) administered to carp fry can be utilized by the fry to facilitate growth and development if it contains the basic nutritional requirements and palatability for fish consumption. Chicken egg yolk, although demonstrated good growth performance, it could not be compared to the commercial Artemia. This was evident in the significant mean weight gain by carp fry fed Artemia, commercial starter feed and smashed egg yolk, respectively. smashed egg yolk may therefore be tried on other fish species to compare performances with the findings of this study.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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