Experimental Culture of the Giant Freshwater Prawn, *Macrobrachium vollenhovenii* (Herklots, 1857) around the FUTO Axis of Otamiri River, Imo State, Nigeria

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Abstract: Culture trial of 7,488 juveniles of the giant freshwater prawn, *Macrobrachium vollenhovenii* (Herklots, 1857) was carried out for 180 d in concrete tanks to determine their adaptability, survival, feed utilization and growth performance under culture condition. Twelve experimental concrete tanks each measuring 10 m × 5 m × 1.0 m were used for the experiment from March to August 2016. The prawns were stocked two weeks after treatment of tanks with agricultural lime at the rate of 2,279 kg/ha and poultry manure at the rate of 114 kg/ha. Four experimental diets tested were designated as T₁: powdered broiler starter, T₂: commercial brine shrimp, T₃: combination of broiler starter and brine shrimp and T₄: Mississippi Agricultural and Forestry Experimental Station (MAFES) diet formula. Diets were randomly assigned to the four treatment tanks and replicated three times in a 4 × 3 = 12 experimental units as a completely randomized design experiment (CRD). Each tank was stocked with 624 juvenile prawns with mean total length of 1.5 cm and body weight of 10.0 g. Prawns were fed at 5% body weight and twice at 0600 h and 1800 h. Sampling for growth was carried out bi-weekly while water quality was tested weekly. Results were statistically evaluated with one way analysis of variance (ANOVA). Water quality of the four tanks was not significantly different ($p > 0.05$) from one another throughout the culture period and conformed to recommended tolerable limits in prawn culture ponds. Growth performance was best in diet T₄ (the MAFES formula), with a survival rate of 75%, mean weight gain (MWG) of 65 g, relative growth rate (RGR) of 650%, specific growth rate (SGR) of 1.12%, average daily growth (ADG) of 0.3 g/day and food conversion ratio (FCR) of 1.44. The above values differed quite significantly ($p < 0.05$) from growth responses of other diets. The computed gross ratio (GR) of 0.62 suggests that prawn culture is a highly lucrative business.

Key words: Culture trial, *Macrobrachium vollenhovenii*, Otamiri River banks, Nigeria.

1. Introduction

Nigeria is blessed with abundant freshwater shellfish resources, one of which is the giant freshwater prawn, *Macrobrachium vollenhovenii* (Herklots, 1857) which is abundant in the wild within the Niger-Benue floodplains around Otuocha and Odekpe in Anambra state and Idah in Benue state as well as in the Niger Delta estuaries. If commercially exploited in culture systems, the proceeds will greatly reduce fish importation and help conserve foreign

exchange for Nigeria. The National Program for Food Security [1] reports that shrimps and prawns are the world's most important sea food commodity and accounts for 19% of international trade in value terms, adding that it constitutes Nigeria's highest foreign exchange earning fishery product with over US\$50 annually. While prawn culture business and technology is advanced in countries of South East Asia, Europe and America [2, 3], it is a relatively new phenomenon in Nigeria with sketchy information [4-6]. There is no known documented comprehensive report on successful culture of prawns in Nigeria. The giant freshwater prawn (*M. vollenhovenii*) is

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considered to hold the greatest potentials for culture as it is the largest of the palemonid prawns in Nigeria, reaching a total length of 182-195 mm [7], has high commercial value [8], and with broodstocks and juveniles available in the wild for culture proposes [7].

The objectives of the study was to evaluate the possibility of rearing the giant freshwater prawn, *M. vollenhovenii*, in captivity with a view to determining the adaptability of the prawn in captive ponds, as well as the survival, feed utilization and growth performance in culture conditions.

2. Materials and Methods

2.1 The Study Area

The experiment was carried out at the Federal University of Technology Owerri (FUTO), on the banks of the FUTO axis of the Otamiri River which transverses the university. Federal University of Technology Owerri lies within latitude 5.4833° N of the equator and longitude 7.0333° E of the Greenwich meridian in the humid tropical rainforest region of West Africa. It has a mean annual rain fall of about 1,850 mm and mean annual temperature of about 28 °C. The area has high relative humidity that varies from 75% to 90%. The climate of the region is distinguished into two distinct seasons, the rainy season which lasts from March to October and the dry season which is experienced between November and March.

2.2 Experimental Design and Data Collection

The study was designed as a completely

randomized design experiment (CRD) with four treatments replicated three times in a $4 \times 3 = 12$ experimental tank units. The mathematical model [9] is as follows:

$$\text{CRD, } X_{ij} = M + T_i + E_{ij} \quad (1)$$

where X_{ij} = value of independent observation; M = value of the unknown population variable; T_i = treatment effect; E_{ij} = experimental error.

The study was aimed at testing four different dietary treatments, designated as follows:

T₁: powdered broiler starter;

T₂: commercial brine shrimp;

T₃: a combination of broiler starter and brine shrimp;

T₄: Mississippi Agricultural and Forestry Experimental Station (MAFES) dietary formula.

Four concrete tanks, each measuring 10 m × 15 m (150 m²) were constructed. Each was subsequently demarcated into three sub-units, each measuring 10 m × 5 m with an area of 50 m², giving a total of $4 \times 3 = 12$ experimental tank units. Each treatment tank was assigned 624 juvenile prawns and replicated three times. Thus each treatment combination received a total of 1,872 prawns and 2,496 per replicate experiment for all the treatments. Consequently a total of 7,488 juvenile prawns were used for the trial. The treatment diets were then randomly allocated to the replicate tanks. The layout of the experiment is as shown in Table 1.

2.3 Pond Construction and Conditioning

The newly constructed concrete tanks were treated

Table 1 The design layout of the dietary trial of the freshwater prawn.

Treatment	Replicates			Total
	R1	R2	R3	
T ₁ : broiler starter + prawn (control)	A (624)	B (624)	C (624)	1,872
T ₂ : brine shrimp + prawn	B (624)	C (624)	D (624)	1,872
T ₃ : brine shrimp and broiler starter + prawn	C (624)	D (624)	A (624)	1,872
T ₄ : MAFES dietary formula + prawn	D (624)	A (624)	B (624)	1,872
Total	2,496	2,496	2,496	7,488

A, B, C, D = treatment diets randomly assigned to replicates;

Figures = number of prawns assigned to treatments and replicates.

with lime and then fertilized. Agricultural lime (45%-54% CaO) and ground limestone (30%-40% CaO) were applied at the rate of 2,270 kg/ha and 140 kg/ha, respectively [10] to reduce acidity of the concrete tanks. Similarly poultry droppings (manure) were used to fertilize the tanks at the rate of 114 kg/ha [10]. This was supplemented with chemical fertilizer, NPK 15:15:15, applied at the rate of 20-30 kg/ha [4]. The fertilizer promoted the development of plankton which served as the starter food of the juvenile prawns.

2.4 Collection of Juveniles and Stocking

2.4.1 Collection and Transportation

Juvenile prawns were collected from the Atani and Odekepe flood plans of the Niger-Benue drainage system in accordance with MAFES (1981) in five oxygenated polyethylene bags each containing 1,500 juveniles and a total of 7,500. The prawns weighed 10.0 g in mean body weight (MBW) and 1.5 cm in mean total length. Crushed ice and saw dust stuffed between the bags in a plastic bucket lowering the temperature to about 20 °C during transportation.

2.4.2 Stocking

The ponds were stocked with the prawns two weeks after preparation/conditioning. Prior to stocking, the physio-chemical parameters of the pond water were tested and certified as per requirement of prawn, 7,488 out of 7,500 juveniles survived during the transportation. The pond was stocked at the rate of 30 juveniles/m² [2, 4].

The polythene bags were allowed to float in the pond water for a while to enable the water temperature of the two media to equate before the prawns were released free in the tanks.

2.5 Laboratory Methods and Data Collection

2.5.1 Soil and Water Analysis

Particle size analysis of the soil samples was carried out in the laboratory in accordance with standard method of Ref. [11], while standard analytical methods [12-14] were adopted in determining the physico-chemical parameters of water. Parameters evaluated include temperature (*in situ*), total hardness (EDTA titrimetric method), pH (pH meter), dissolved oxygen (the Winkler method), carbon dioxide (titrimetric method), nitrite-nitrogen (spectrophotometric method), and ammonia-nitrogen (Nesler method). Soil analysis helped in determining the kind of pond to use based on its ability to retain water.

2.5.2 Composition of Experimental Diets and Feeding

Experimental diet 1 (powdered broiler starter): this is the standard supplemental diet for prawns in the Mauritius for *Macrobrachium rosenbergii* [2]. The broiler starter was first wetted and compacted into balls with binder (starch) before dispensing into the water to prevent it from floating.

Experimental diet 2 (decapsulated commercial brine shrimp (*Artemia salina*)): this was suggested by the MAFES [15], especially at the larval and post larval stages of the prawn. The brine shrimps were hatched following the methodology of Ref. [15].

Experimental diet 3: this consisted of a combination of brine shrimp and broiler starter.

Experimental diet 4 (MAFES dietary formula): this special formulation was developed by the MAFES [15], and was composed as shown in Table 2.

Table 2 Ingredient composition of the MAFES supplemental diet for prawns.

Ingredient	Wet composition (%)
Fish powder (or cleaned squid)	85.00
Cod liver oil	2.00
Eggs	10.00
Beef liver powder	3.00
Total	100.00

The fish was processed by removing the scales, eyes and bones. It was then cooked in a microwave oven for 7-8 min, dried and blended. The chicken eggs, cod liver oil and the dried and ground beef liver powder were mixed together with the fish homogenate. Starch binder was gradually added while mixing continued until a paste was formed. The paste was put in a bucket containing 4-5 g/L of calcium chloride (CaCl_2) for further binding. After forming a rubbery texture, the paste was pelleted in a milling machine using a 1.6 mm die. Pellet size was increased as the prawns grew bigger.

2.5.3 Feeding and Growth Sampling

The prawns were fed at 5% body weight [4], two to three times daily at 0600 h and 1800 h. Feeds dried to 80% moisture were always dropped at designated four corners of the tank. The prawns were sampled fortnightly for growth while water quality was monitored weekly.

2.5.4 Harvesting and Growth Analysis

The prawns were harvested after six months of culture trial (March to August 2016). All the prawns were harvested and data collected for the computation of survival rate, cost-benefit-analysis and the following growth parameters: average daily growth (ADG), specific growth rate (SGR), mean weight gain (MWG) and food conversion ratio/feed utilization (FCR).

The growth parameters were estimated [16] as follows:

$$\text{Percentage weight gain} = (W_f - W_i \times 100) / W_i \quad (2)$$

where W_f = final body weight (g); W_i = initial body weight (g).

$$\text{Relative growth rate (RGR) (\%)} = (\text{weight gain} \times 100) / \text{initial body weight} \quad (3)$$

$$\text{SGR} = (\log W_f - \log W_i) \times 100 / t \quad (4)$$

where W_f and W_i = final and initial weight of fish; t = rearing period of prawn.

$$\text{ADG (g)} = (\text{final MBW} - \text{initial MBW}) / \text{culture period (days)} \quad (5)$$

where MBW = mean body weight (g).

$$\text{FCR (wet weight basis)} = \text{feed fed (g)} / \text{rearing period of prawns (days)} \quad (6)$$

$$\text{Survival rate (\%)} = (\text{number of prawns at the end of experiment} \times 100) / \text{total number of prawns stocked} \quad (7)$$

2.6 Statistical and Economic Analysis

Data collected were analyzed with one-way analysis of variance (ANOVA). The Duncan's multiple range test [17] was employed for treatment separation to detect the significance of difference in mean treatment effects. For the purpose of this, the Statistical Computer Package for Social Science (SPSS), window 7, version 18 was employed.

Economic analysis of the trial was based on gross ratio (GR) following the methodology of Ref. [18] as follows:

$$\text{GR} = \text{fixed cost} / \text{gross revenue} \quad (8)$$

3. Results and Discussion

3.1 Soil Analysis

Table 3 shows the results of the soil particle size analysis of the experimental site.

The results revealed that the soil was sandy and porous [11] and unsuitable for earthen ponds and prawn culture. Consequently concrete tanks were adopted for the research.

3.2 Physico-chemical Properties of Otamiri River around FUTO Axis

The results of the physico-chemical analysis of Otamiri River around the project site are presented in Table 4.

The result shows that mean temperature remained 29.0 ± 2.0 °C, transparency 40.0 ± 2.5 cm, pH 8.7 ± 1.9 , dissolved oxygen 9.4 ± 2.0 mg/L, carbon dioxide 3.8 ± 0.5 mg/L, total dissolved solids 76.7 ± 8.5 mg/L. Comparison between stations did not show any significant difference in these parameters.

The above data on water quality show that water from the river was ideal for biological life and conforms

Table 3 Results of particle size analysis of soils around the FUTO axis of Otamiri River compared with USDA classification.

USDA particle size scale (cm)	USDA name for particle size	Proportion of particle size fractions (%)			
		This study	USDA classification for different soils		
			Loam soil	Sandy soil*	Clay soil
2.00-0.05	Sand	69.1	40	70	10
0.05-0.002	Silt	25.4	40	20	30
Less than 0.002	Clay	5.5	20	10	60

*Confirmed soil type of FUTO axis of Otamiri River banks.

Table 4 Physico-chemical parameters of water around the FUTO axis of Otamiri River.

Parameter	Stations			± S.D.
	A	B	C	
Temperature (°C)	29.1 ^a	28.8 ^a	29.0 ^a	29.0 ± 2.0
Transparency (cm)	40 ^a	39.9 ^a	41 ^a	40.0 ± 2.5
pH	8.6 ^a	8.4 ^a	9.0 ^a	8.7 ± 1.9
Dissolved oxygen (mg/L)	10.0 ^a	8.8 ^a	9.5 ^a	9.4 ± 2.0
CO ₂ (mg/L)	4.0 ^a	3.7 ^a	3.8 ^a	3.8 ± 0.5
TDS (mg/L)	85.0 ^a	75.0 ^a	70.0 ^a	76.7 ± 8.5

^{abc} mean values in the same row with similar superscripts are not significantly different at $F\alpha = 0.05$.

with recommended values for fish and prawn culture [10, 19, 20].

3.3 Water Quality Parameters of Experimental Tanks

Table 5 shows the water quality parameters of the prawn tanks evaluated on weekly basis during the trial.

All the parameters fell within the tolerable and recommended limits for aquaculture. Ref. [10] recommended total hardness between 50 mg/L and 300 mg/L; pH of 6.5 to 9.0 and dissolved oxygen of 5-15 mg/L in fish ponds. Refs. [12, 20] both recommended biological oxygen demand (BOD) of 10 mg/L and chemical oxygen demand (COD) of 50-70 mg/L as ideal for fish culture.

The high values of total ammonia (0.21 mg/L) and phosphate (5.5 mg/L) recorded in T₄ (though within acceptable limits in aquaculture) may be associated with the decomposition of left over food in this tank being the only formulated diet in the trial. This may also account for the low pH value (6.5) and dissolved oxygen (6.8 mg/L) in the same tanks. The highly alkaline water in T₂ (pH 9.8) and high level of dissolved oxygen (9.0 mg/L) may be attributed to the

fact that the diet is a live organism with little chance of water pollution.

3.4 Growth Performance of Experimental Prawns and Diets

The growth responses of the experimental prawns to the different dietary treatments are summarized in Table 6.

3.4.1 Survival

In treatment diet T₁, 1,311 prawns out of 1,872 stocked survived, with a survival rate of 70%. In treatment diet T₂, 1,498 survived out of 1,872, gave a survival rate of 80%. In diets T₃ and T₄, the same number of prawns (1,404) survived with same survival rate of 75%. There was no discernible difference ($p > 0.05$) in survival rate of prawns between the treatment diets.

3.4.2 Growth Parameters

The result on growth response shows that during the culture trial of 180 d, the prawns increased in MBW from 10 g to 45.0 g in T₁, 35.0 g (T₂), 50.5 g (T₃) and 75.0 g (T₄) with MWG of 35 g in T₁, 25 g (T₂), 40.5 g (T₃) and 65.0 g (T₄). Diet T₄ (MAFES formula) gave the highest MWG of 65.0 g which was

Table 5 Water quality parameters of the four treatment tanks during the prawn culture trial.

Parameters	Treatment tanks/diets			
	T ₁	T ₂	T ₃	T ₄
Temperature (°C)	27.8 ^a	28.0 ^a	28.5 ^a	28.0 ^a
Total hardness (mg/L)	65.60 ^a	70.0 ^a	65.0 ^a	68.0 ^a
Turbidity/transparency (cm)	25.0 ^a	28.0 ^b	25.5 ^a	26.0 ^a
Dissolved oxygen (mg/L)	7.5 ^a	9.0 ^b	8.5 ^b	6.8 ^c
pH	7.5 ^a	9.8 ^b	8.0 ^a	6.5 ^c
BOD (mg/L)	9.5 ^a	8.0 ^b	8.5 ^b	10.0 ^a
COD (mg/L)	35.0 ^a	32.5 ^b	34.6 ^b	40 ^a
Phosphates (mg/L)	5.0 ^a	3.5 ^b	4.8 ^a	5.5 ^a
Total ammonia (mg/L)	0.15 ^a	0.08 ^b	0.10 ^b	0.21 ^c

^{abc} mean values in the same row with different superscripts are significantly different at $F \propto 0.05$.

Table 6 Growth performance of experimental prawns to dietary treatments during 180 d culture trials.

Growth parameters	Treatment diets			
	T ₁	T ₂	T ₃	T ₄
Initial mean weight (g)	10.0 ^a	10.0 ^a	10.0 ^a	10.0 ^a
Final mean weight (g)	45.0 ^a	35.0 ^b	50.5 ^a	75.0 ^c
Mean weight gain (MWG) (g)	35.0 ^a	25.0 ^b	40.5 ^a	65.0 ^c
Number of prawns stocked	1,872	1,872	1,872	1,872 ^a
Number that survived at harvest	1,311 ^a	1,498 ^b	1,424 ^c	1,404 ^c
Rearing period (d)	180	180 ^b	180	180
Survival rate (%)	70 ^a	80 ^a	75 ^a	75 ^a
Relative growth rate (RGR) (%)	350 ^a	250 ^b	405 ^b	650 ^c
Specific growth rate (SGR) (%)	0.84 ^a	6.98 ^b	8.98 ^c	1.12 ^d
Average daily growth (ADG) (g)	0.19 ^a	0.14 ^b	0.23 ^a	0.36 ^c
Food conversion ration (FCR)	2.70 ^a	3.74 ^b	2.30 ^a	1.44 ^c

^{abc} mean values in the same row with different superscripts are significantly different ($p < 0.05$).

Table 7 Cost-benefit analysis of the prawn culture trial around the FUTO axis of Otamiri River, with pay back period of two years.

S/N	Operation	Cost (N)*	Revenue (N)
A	Cost		
	Capital cost		
	Site selection		
1	Shore line survey	50,000.00	
	Clearing and stumping	52,000.00	
	Soil and water test	60,000.00	
2	Tank construction (concrete)	300,000.00	
3	Tank preparation/conditioning	88,000.00	
		550,000.00	
	Current cost		
4	Prawn procurement	120,000.00	
5	Feeding	230,000.00	
6	Miscellaneous	100,000.00	
		450,000.00	

(Table 7 continued)

S/N	Operation	Cost (N)*	Revenue (N)
B	Total cost	100,000.00	
1	Total weight of prawn harvested = 295.539 kg		
2	Farm gate price = N3,000/kg		
3	Total revenue (sales income)		886,517.00

*Figures in Nigerian Naira, NGN (N).

significantly higher ($p < 0.05$) than those of other diets. Dietary treatment T_2 (decapsulated brine shrimp) recorded the least MWG (25.0 g).

RGR was 350% in T_1 , 250% in T_2 , 405% in T_3 and 650% in T_4 . SGR was 0.84% (T_1), 6.98% (T_2), 8.98% (T_3) and 1.12% (T_4). ADG was 0.19 g/d (T_1), 0.14 g/d (T_2), 0.23 g/d (T_3) and 0.36 g/d (T_4). FCR was 2.70 (T_1), 3.74 (T_2), 2.30 (T_3) and 1.44 (T_4). Diet T_4 (MAFES formula) performed best in all the growth parameters with values statistically different ($p < 0.05$) from the other diets. The least was diet T_2 (live *Artemia*) with FCR of 3.74.

Values of the FCR suggest that the juvenile prawns effectively utilized the compounded MAFES diet (FCR = 1.44) more than the other diets (FCR = 2.70 for T_1 , 3.74 for T_2 and 2.30 for T_3). FAO [4] reported that FCR of 1.2-1.5 is ideal and suggestive of acceptability, efficient food utilization and good growth in prawns. Ref. [2] recorded an MBW of 35.31 g, ADG of 0.119 g/d to 0.3640 g/d, and FCR of 1.0 to 2.5 in *M. rosenbergii* cultured for 154 d as good performance. The stocking density and feeding regime adopted may have contributed to the good performance of the prawns. According to Ref. [4], optimum growth performance in intensive prawn culture systems requires high stocking density of 25-30 juveniles/m² with feeding rate of 3-4 times daily at 3%-5% body weight.

3.5 Economic Analysis

Financial transaction of the dietary trial was subjected to economic analysis, using the cost/benefit analysis (CBA) as presented in Table 7.

The financial analysis (Table 7) shows that the total

cost of investment including capital cost and recurrent expenditures were almost written off from the proceed of the first year of operation. A paltry deficit of only N113,383.00 was recorded. In the second year of operation (given the same revenue of N886,617.00), the recurrent cost of N450,000 together with the outstanding deficit of N113,383 from the previous year was all defrayed, leaving a profit margin of N323,234.00, computed thus:

$$\begin{aligned} 1^{\text{st}} \text{ year (revenue - cost)} &= \text{N}886,617 - \text{N}1,000,000 \\ &= -\text{N}113,383 \text{ (deficit)} \end{aligned}$$

$$\begin{aligned} 2^{\text{nd}} \text{ year: profit/loss} &= (\text{total revenue} - \text{total cost}) \\ &= [\text{N}886,617 - (\text{N}450,000 + \text{N}113,383)] \\ &= \text{N}886,617 - \text{N}563,383 \\ &= \text{N}323,234.00 \text{ (profit)} \end{aligned}$$

4. Conclusions and Recommendation

From the economic analysis, it can be seen that prawn culture business is a highly lucrative venture if properly managed. It is advocated that this industry should be developed in Nigeria as it is in South East Asia, Europe and America through research and commercial production. The MAFES innovative diet is recommended for use. There is the need to kick-start with brood stock development in standard brackish water hatcheries, and further culture trial is encouraged.

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