

Comparative study of *Artemia* (Brine shrimp) and *Ceriodaphnia* (Zooplankton) as foods for catfish larvae

Ajepe RG¹, Hammed AM¹, Amosu AO^{2*}, Fashina-Bombata HA¹

¹Department of Fisheries, Faculty of Science, Lagos State University, P.O.Box 0001, LASU Post Office, Ojo, Lagos-Nigeria

²Department of Biodiversity and Conservation Biology, Faculty of Natural Science, University of Western Cape, Private Bag X17, Bellville, 7535, South Africa

Authors' contributions

This work was carried out in collaboration between all authors as team work. Author ARG was responsible for the initial idea and study design. Authors ARG, HAM and AAO collected and compiled all information, and performed the experiment. Authors ARG and HAM worked with authors AAO and FHA in data analysis and interpretation. All authors contributed to the editing, revision, and final preparation of the manuscript. All authors have read and approve the final manuscript.

Research Article

ABSTRACT

Artemia and *Ceriodaphnia* were used as “first food” for the larvae of *Clarias gariepinus*, *Heterobranchus bidorsalis* and their hybrid *Heteroclarias* in order to determine if *Ceriodaphnia* could effectively replace *Artemia* in Nigeria in the production of Catfish fingerlings. The 5-day old fry of *C. gariepinus*, *H. bidorsalis* and *Heteroclarias* weighing 18.5mg, 14.0mg and 13.5mg respectively were stocked in plastic tanks and fed with *Artemia nauplii* and *Ceriodaphnia dubia* for 21 days. Growth indices such as Percentage Survival (PS), Specific Growth Rate (SGR), Daily Growth Rate (DGR) and Percentage Weight Gain (PWG) were determined. Measurement of weight changes was performed weekly. At the end of the experiment, PS, SGR, DGR and PWG were slightly better in *Ceriodaphnia*-fed fry of the three species, though the composition of crude protein in *Artemia nauplii* (63.0%) was higher than that of *Ceriodaphnia* (58%). However, analysis of variance (ANOVA) did not reveal any significant ($P>0.05$) in the performance of the two experimental foods. The study reveals the potential of *Ceriodaphnia dubia* as natural food for catfish larvae to produce fast growing species of *C. gariepinus* (Burchell, 1822), *H. bidorsalis* (Geoffroy, 1809) and *Heteroclarias* (reciprocal hybrid). The economic benefits of this study therefore reveals *Ceriodaphnia* as a good replacement for *Artemia*, which has inherent problem of high cost, scarcity, hatching difficulties and sometimes the question of viability of cysts.

Keywords: *Artemia*, *Ceriodaphnia*, *Clarias gariepinus*, *Heterobranchus bidorsalis*, *Heteroclarias*

* +27744413588, aamosu@uwc.ac.za

1. INTRODUCTION

The catfish families are among the most valued fresh and marine water fish species in West Africa. **Clarrid catfishes** of the genera *Clarias* and *Heterobranchus* are highly esteemed in Nigeria and command very high commercial value in our markets (1). They are very hardy and have accessory air breathing organs, which enable them to tolerate low dissolved oxygen levels and other adverse aquatic condition where most cultivable species cannot survive. With these unique characteristics of this omnivore, their fingerlings are scarce due to inadequate hatchery techniques and insufficient live food of high quality which is a major setback to fish farmers.

Clarias and *Heterobranchus* species are very popular among Nigerian fish farmers. Considerable interest had been generated in the growth potential of ***C. gariepinus*** and *Heterobranchus* spp. However, because of the need for fast growing fingerlings that will satisfy the culture requirements and market value of fish farmers, *Heteroclaris* (2), which is the hybrid of *Clarias* and *Heterobranchus*, came into being.

It has been noted that these species are very important to the sustainability of aquaculture industry particularly in tropical countries. However, in spite of the break through recorded in the artificial propagation of these species, demand for the fingerlings still outstrips the supply. The difficulties being encountered in rearing hatchlings to fingerlings is the major cause of demand outstripping supply for catfish fingerlings in Nigeria.

Lack of suitable feed as the main cause of mortality in catfish fry management and points out that the food must be adequate not only in quality but also in quantity (3, **4 and 5**). Therefore, feeding has been recognized as the major problem in the management of clariids hatchlings to fingerlings (4).

Live food in feeding fry and fingerlings is obligatory for successful development of catfish aquaculture (4). However, aquaculture research suggested rotifers (Zooplankton) as the most satisfactory "first food" for fry (6, 7 and 8). It has been revealed that within the first two weeks of life, the food of *Clarias* hatchlings should entirely be zooplankton and are healthy for most fish species since it leads to better larvae growth (9 and 10). Report show that *C. gariepinus* requires, after yolk sac absorption an initial phase of exogenous feeding with natural, preferably live food organisms such as *Artemia nauplii* meet their nutritional requirements for optimization of growth and survival at this stage (3 and 11). *Artemia nauplii* are being used today to feed fish larvae all over the world including Nigeria. However, high cost of *Artemia* cysts, problem of hatching and irregularity in supply had been the bane of many Nigeria catfish farmers that depended entirely on the use of *Artemia*. Therefore there is need for better alternatives.

Live organisms, particularly Rotifers, *Cladocerans* and *Artemia* have been used in the large scale rearing of African catfish larvae. However, the collection of live food from the wild is cumbersome and only available on a seasonal basis, and *Artemia* is expensive particularly for hatcheries in developing countries in Africa. Additional benefit for commercial fingerling producers may reduce the need and the stress required in harvesting fingerlings from culturing chambers and transporting them to holding tanks prior shipping to growers (12).

The research was therefore aimed at comparing the performance of *Ceriodaphnia* with *Artemia nauplii* in feeding of *C. gariepinus* (Burchell, 1822), *H. bidorsalis* (Geoffroy, 1809) and *Heteroclaris* spp (reciprocal hybrid) frys and also, to determine if *Ceriodaphnia* can successfully replace *Artemia* in the aquaculture production of African catfish fingerlings.

2. MATERIAL AND METHODS

2.1 Experimental fish

Mature males and females of *C. gariepinus* and *H. bidorsalis* were selected and artificially spawned in the hatchery with ovaprim injected intramuscularly in a single dose of 0.5ml/kg fish weight. The ripe-running eggs were stripped and fertilized with milt as follows:

i.	<i>Clarias gariepinus</i> (Male)	X	<i>C. gariepinus</i> (Female)
ii.	<i>Heterobranchus bidorsalis</i> (Male)	X	<i>H. bidorsalis</i> (Female)
iii.	<i>Heterobranchus bidorsalis</i> (Male)	X	<i>C. gariepinus</i> (Female)

The larvae produced from the above parental species and hybrid was reared in three separate bowls for five days at the end of which the yolk was completely absorbed. After absorption of the yolk sac, the mean length ($\pm$ SD) of each larvae of *C. gariepinus* (8.75 ± 0.25 mm), *H. bidorsalis* (8.00 ± 0.00 mm) and *Heteroclarias* (8.50 ± 0.04 mm) was measured respectively.

2.2 Collection and preparation of experimental foods

The *Ceriodaphnia* (fig. 1a.) used for this study were collected daily with zooplankton net from a wetland located close to the Lagos State University, Ojo, Nigeria . This zooplankton was confirmed to be *Ceriodaphnia* when examined under microscope with the aid of FAO plankton identification sheet in the fisheries laboratory prior to the commencement of the experiment. The proximate analysis of *Ceriodaphnia* was carried out in a laboratory at the Department of biological Sciences, Federal University of Agriculture Abeokuta Ogun State.

A tin of Vacuum-packed *Artemia* cysts (PRO 80) was purchased from a local supplier and hatched in the hatchery unit of department of fisheries, Lagos State University as directed by the manufacturer (Ocean Star International, INC. Snowville, UT. 84336 U.S.A.).

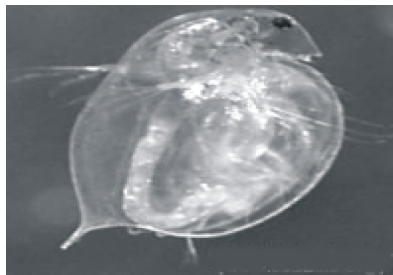


Fig. 1a: *Ceriodaphnia dubia*



Fig. 1b: *Artemia nauplii*

Figure 1: (a) daphnia with body enclosed by an uncalcified shell (carapace) (b) artemia cysts hatched to provide live nauplii fish larvae

2.3 Feeding of fish larvae

Twelve circular plastic tanks each containing 20 litres of water from borehole supplied with aeration devices (Aquarium Fish Tank Oxygen Air Pump Hydroponics YT 301C, [http: www.sunsun.china.com](http://www.sunsun.china.com)) were used for the feeding experiment. The tanks were covered with mosquitoes net to prevent insect predators from entering. The twelve tanks were grouped into three A, B and C (i.e. four tanks per group; A (i-iv), B (i-iv) and C (i-iv). Each group of *C. gariepinus*, *H. bidorsalis* and *Heteroclaris* were stocked with 200 fry and fed *adlibitum* twice daily for 21 days.

Table 1: Different groupings and treatment methods adopted in feeding the fry for 21 days

Groupings		Treatment
A	Tanks i and ii	Fry fed with <i>Ceriodaphnia</i>
	Tanks iii and iv	Fry fed with <i>Artemia nauplii</i>
B	Tanks i and ii	Fry fed with <i>Ceriodaphnia</i>
	Tanks iii and iv	Fry fed with <i>Artemia nauplii</i>
C	Tanks i and ii	Fry fed with <i>Ceriodaphnia</i>
	Tanks iii and iv	Fry fed with <i>Artemia nauplii</i>

2.4 Statistical analysis

Growth indices such as percentage survival, specific growth rate, daily growth rate and percentage weight gain resulting from the experiment were subject to one-way analysis of variance (ANOVA (13)) and levels of significance of the experimental data were determined at 5% confidence limit using Bayesian Multiple Comparisons and Multiple Tests [BMCMT] (14).

3. RESULTS

Table 2: Proximate composition (%) of the experimental foods

Nutrient	<i>Artemia nauplii</i>	<i>Ceriodaphnia</i>
Moisture	84.5	92.0
Crude protein*	63.0	58.8
Lipid*	18.2	17.9
Fibre*	8.5	7.1
Ash*	0.9	1.5

* On dry matter basis

There were slight differences in the proximate composition of *Artemia nauplii* and *Ceriodaphnia dubia*. The crude protein, lipid and fibre contents of Artemia (63.0%, 18.2% and 8.5%) were higher than that of

Ceriodaphnia whereas, Ceriodaphnia on the other hand had higher moisture content (92.05) and ash (1.5%).

Table 3: Growth performance and Survival rate of *C. gariepinus*, *H. bidorsalis* and *Heteroclaris* Fry fed *Artemia nauplii* and *Ceriodaphnia dubia* for 21 days (Mean±SD)

Parameters	<i>Artemia nauplii</i>			<i>Ceriodaphnia dubia</i>		
	<i>C. gariepinus</i>	<i>H. bidorsalis</i>	<i>Heteroclaris</i>	<i>C. gariepinus</i>	<i>H. bidorsalis</i>	<i>Heteroclaris</i>
Initial total length (mm)	9.0±0.35 ^a	8.0±0.00 ^b	8.5±0.00 ^c	8.5±0.34 ^c	8.0±0.00 ^b	8.5±0.00 ^c
Initial body weight (mg)	19.0±0.00 ^a	14.0±0.00 ^b	13.5±0.00 ^b	18.5±0.00 ^a	14.0±0.00 ^b	13.5±0.00 ^b
Final total length (mm)	18.0±0.71 ^a	18.0±1.41 ^a	19.5±1.06 ^a	18.5±0.70 ^a	19.5±1.77 ^a	21.0±0.00 ^a
Final body weight (mg)	91.5±0.35 ^a	80.0±0.00 ^b	100.0±0.00 ^c	140.0±0.71 ^d	125.0±0.35 ^e	170.0±1.41 ^f
Increase in length (mm)	9.0±5.20 ^a	10.0±5.30 ^a	11.0±5.77 ^b	10.0±5.39 ^a	11.5 ±9.05 ^b	12.5±6.38 ^b
Increase in weight (mg)	72.5±37.59 ^a	66.0±34.78 ^a	86.5±46.54 ^a	121.5±65.47 ^b	111.0±60.45 ^{ab}	156.5±86.72 ^c
SGR%	7.49±0.24 ^a	8.30±0.31 ^b	9.54±0.36 ^c	9.64±0.43 ^c	10.43±0.67 ^c	12.06±1.24 ^c
% survival	90.5	85.5	71.5	96.5	96.05	94.5
K (Condition factor)	2.08±0.38 ^a	2.30±0.41 ^a	1.66±0.26 ^a	2.83±0.97 ^b	2.69±0.58 ^b	2.34±0.43 ^a
DGR (mg/fish/day)	0.038±0.01 ^a	0.039±0.00 ^a	0.041±0.00 ^a	0.041±0.01 ^a	0.042±0.01 ^a	0.044±0.02 ^a
PWG (%)	381.6±32.31 ^a	471.4±29.26 ^b	640.7±39.56 ^c	656.8±50.76 ^c	792.8±47.46 ^d	1159.3±68.75 ^e

Values with the same superscript are not significantly different at p=0.05

The highest increase in total length (12.5mm), body weight (156.5g), specific growth rate (12.06%), daily growth rate (0.44mg/day) and percentage weight gain (1159.3%) as shown on table 3 were achieved by *Heteroclaris* fry fed on *Ceriodaphnia*. While the lowest increase in total length (9.0mm) and body weight (66mg) were achieved by *Clarias gariepinus* and *Heterobranchus bidorsalis* fry fed on *Artemia nauplii*. *Clarias gariepinus* fry fed on *Artemia nauplii* also had the lowest specific growth rate (7.49); daily growth rate (0.038mg/day) and percentage weight gain (381.58%). The condition factor (K) was closely related but slightly lower (1.66±0.26) for *Artemia nauplii* fed *Heteroclaris* fry. The highest survival rate (96.5%) was recorded by *Clarias gariepinus* fed on *Ceriodaphnia* while the lowest (71.5%) was recorded by *Heteroclaris* sp fed on *Artemia nauplii*.

4. DISCUSSION

The growth performance of *C. gariepinus*, *H. bidorsalis* and *Heteroclaris* larvae at the end of 21 days feeding trial reveals total length being slightly higher in *Ceriodaphnia*-fed larvae (18.5mm, 19.5mm and 21.0mm) compared with a length of 18.0mm, 18.0mm and 19.5mm recorded for the *Artemia*-fed larvae. The weight was also slightly better in the *Ceriodaphnia*-fed larvae (140.0mg, 125mg and 170mg respectively), compared to the weight of 91.5mg, 80mg and 100.0mg recorded for the *Artemia*-fed larvae. There were slight significant difference in length but wider significant differences in weight (P<0.05) between the three fish larvae fed *Ceriodaphnia* and *Artemia*. Survival rate, specific growth rate (SGR),

condition factor (K), daily growth rate (DGR) and percentage weight gain (PWG) were all slightly higher in the *Ceriodaphnia*-fed larvae compared to the *Artemia*-fed larvae.

The growth of fish is generally believed to be a function of the crude protein level in the diet. In spite of the fact that crude protein level of *Artemia nauplii* (63.0%) was slightly higher than that of *Ceriodaphnia* (58.8%), the latter still perform well in this study. This could be attributed to the fact that catfish larvae may not require more than 58.85 C.P. for optimum growth. The result of this study support the report of (15) who reported 55% crude protein for fry feed and also (16) recommended dietary requirement of not more than 52% crude protein for catfish larvae. Efficient growth of fish depends on feeding the best possible diets at levels not exceeding the dietary needs (17). The relatively longer life span of *Ceriodaphnia* in water as observed during the study, coupled with the fact that *Ceriodaphnia* is a fresh water zooplankton, makes it more available and acceptable to *C. gariepinus*, *H. bidorsalis* and *Heteroclaris* larvae which also dwell naturally in fresh water compared to *Artemia nauplii* which is salt water zooplankton.

The better performance of *Heteroclaris* larvae recorded could be attributed to improved hybrid vigour; since similar experimental foods, rearing conditions and techniques were provided. This agree with the findings of (18, 19, 20 and 21) who observed that hybrid in most cases were superior to the parental strains in growth, food conversion and resistance to diseases.

Survival of larvae ranged from 71.5% to 96.5%. The mortality recorded might be due to handling stress during the experiment. Highest survival rate was obtained in *Ceriodaphnia* diet and the general high survival rate however, could be attributed to proper management of larvae and level of acceptability of the two experimental foods by the fish.

5. CONCLUSION AND RECOMMENDATION

Ceriodaphnia has a great potential as natural food that can produce fast growth rate of *C. gariepinus*, *H. bidorsalis* and *Heteroclaris* spp larvae. The results show that *Ceriodaphnia* could be efficient in catfish larvae rearing and will enhance the aquaculture development in rural areas of Nigeria with little or no access to *Artemia*. The study therefore provides a good replacement for *Artemia*, which has inherent problem of high cost, scarcity, hatching difficulties and sometimes the question of viability of cysts. In spite of the great potential discovered in *Ceriodaphnia* however, collection from the wild is a herculean task; therefore there is need for further research on mass production of *Ceriodaphnia* in culture system with the development of effective culture recipes and techniques that can turn out large quantities of *Ceriodaphnia* throughout the year.

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COMPETING INTERESTS

The authors have declared that no competing interests exist.

REFERENCES

1. Mohammed S, Omoregie E. An investigation into the fisheries potentials of Doma Lake, Nasarawa State. *Journal of Aquatic Science*. 2004; 19: 59-64.
2. Owodeinde FG. A study on the growth and survival of *Clarias gariepinus*, *Heterobranchus bidorsalis* and their hybrids in earthen ponds. *PhD thesis*, Department of Fisheries, Faculty of Science, Lagos State University, Ojo, Lagos, Nigeria. 2007; 240pp
3. Huisman EA. Aquaculture research in the Africa Region. In: *Proceedings of the African Seminar on Aquaculture*. 1985; Vol.1: 7-11.
4. FAO (Food and Agricultural Organization). Seed production. Mass production of fry and fingerlings of the African Catfish *Clarias gariepinus* project reports. 1987; 118p.
5. FAO (Food and Agricultural Organization). *The State of World Fisheries and Aquaculture 2012*, Food and Agriculture Organization of the United Nations. Rome. Italy. 2012.
6. Arimoro FO, Ofojekwu PC. Incidence of feeding, growth and survival of the toothed carp, *Aphyosemion gairdneri* larvae reared on the freshwater rotifer, *B. calyciflorus*. *Trop. Freshwater Biology*. 2003; 12/13: 35-43.
7. Arimoro FO, Ofojekwu PC. Some aspects of the culture, population Dynamics and reproductive rates of the freshwater rotifer, *B. calyciflorus* fed selected diets. *J. Aquatic Science*. 2004; 19: 95-98.
8. Arimoro FO. First Feeding in the African Catfish *Clarias anguillaris* Fry in Tanks with the Freshwater Rotifer *Brachionus calyciflorus* Cultured in a Continuous Feed Back Mechanism in Comparison with a Mixed Zooplankton Diet. *Journal of Fisheries and Aquatic Science*. 2007; 2: 275-284.
9. Madu CT, Basam HD, Isa J, Okwuego C. Optimum dietary protein level for female *Clarias anguillaris* (L) broodstock. *J. Fisheries Technology*. 2000; 2: 57-65.
10. Wang C, Xie S, Zheng K, Zhu X, Lei W, Yang Y. Effects of live food and formulated diets on the survival, growth and protein content of feeding larvae of *Pelteobagrus fulvidraco*. *J. Applied Ichthyology*. 2005; 21: 210-214.
11. Shiri HA, Charlery D, Auwerx J, Vught J, Slycken J, Dhert P, Sorgeloos P. Larval rearing of burbot (*Lota lota*) using *Brachionus calyciflorus* rotifer as starter food. *J. Applied Ichthyology*. 2003; 19: 84-87.
12. Yap WG, Villaluz AC, Soriano MGG, Santos MN. Milkfish production and processing technologies in the Philippines. Milkfish Project Publication Series. 2007; No.2; 96 pp.
13. Arimoro F. First Feeding in the African Catfish *Clarias anguillaris* Fry in Tanks with the Freshwater Rotifer *Brachionus calyciflorus* Cultured in a Continuous Feed Back Mechanism in Comparison with a Mixed Zooplankton Diet. *Journal of Fisheries and Aquatic Science*. , 2007; 2: 275-284.

14. Westfall PH, Tobias RD, Rom D, Wolfinger RD, Hochberg Y, Chapter 13--Bayesian multiple comparisons and multiple tests. in *Multiple Comparisons and Multiple Tests Using the SAS System* (Cary, North Carolina, SAS Institute, 1999).
15. Robinson E. Catfish Nutrition. *Review of Aquatic Sciences*. 1989; 1: 365-391.
16. NRC (National Research Council). *Nutrient Requirement of fish National Academic of Science*, Washington, D.C U.S.A. 2000; 78pp.
17. Aderolu AZ, Seriki BM, Apatira AL, Ajaegbo CU. Effects of feeding frequency on growth, feed efficiency and economic viability of rearing African catfish (*Clarias gariepinus*, Burchell 1822) fingerlings and juveniles. *African Journal of Food Science*, 2010; 4(5): 286 – 290.
18. Ojutiku RO. Comparative Survival and Growth Rate of *Clarias gariepinus* and *Heteroclarias* Hatchlings Fed Live and Frozen Daphnia. *Pakistan Journal of Nutrition*, 2008; 7 (4): 527-529.
19. Jensen J, Durham R, Flynn J. Production of Channel catfish fingerlings. *Circular ANR-327 Alabama Cooperative Extension Service*, Auburn University, Alabama. U.S.A. 1983; 19-21
20. Madu CT, Ita EO. Comparative growth and survival of hatchlings of *Clarias* sp; *Clarias* hybrid and *Heterobranchus* sp. Under indoor hatchery system. *NIFFR Annual Report*. 1991; 47-50
21. Salami AA, Fagbenro OA, Sydenham DHJ. The production and growth of hybrids in concrete tanks. *Israel Journal of Aquaculture Bamidgeh*. 1993; 45(1): 18-25.