IJAAAR 10 (1&2): 188-197, 2014 *International Journal of Applied Agricultural and Apicultural Research*

Cost Characteristics of the African Catfish Culture in Recirculating Production Facilities in Ibadan, Oyo State, Nigeria

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Abstract

Recirculating fish production technology re-uses water more than once by passing it through treatment processes thereby utilizing less water and space required by conventional ponds to produce similar yields of fish. Economic performance of the African catfish in three recirculating fish production facilities in Ibadan metropolis was investigated. Data were obtained using structured questionnaires, physical inspection of facilities, fish sampling and laboratory analysis of water quality parameters were also carried out using standard methods. Facilities sustained African catfish (Clarias gariepinus) loading capacity of 98.1kg/m^3 and 176.6kg/m^3 of juvenile and adult fish with feeding rates of 2.14kg/m^3/day and 1.29kg/m^3/day respectively. Stocking densities are 20,000-31,000fish/m^3; 6000-9000fish/m^3 and 150 – 300fish/m^3. SR varies from 75-80% for fingerlings, 75-93% for juveniles and 77-88% for adult fish. Food Conversion Ratio also ranged from 0.60–0.78 for fingerlings, 1.01-2.08 for juveniles and 1.15-1.68 for grow out system. In all cases, variable cost accounts for more than 75% of total cost. Within fixed costs input, interest payment on initial investment ranks the highest. While feed cost accounts for the highest among variable costs for fingerlings and growout systems. With 50%, 45% and 40% crude protein feeds, production cost per fish was ₦5.40, ₦18.49 and ₦209.0($0.03,$0.11 and $1.31) for fingerling, juvenile and adult fish of average weight 4.2g, 11.2g and 981.0g reared for 28, 30 and 154 days respectively.

Keywords: Profit, Aquaculture, Stocking density, Re-use, Intensive Management.

Introduction

A variety of factors such as socio-economic, legal, technical, political, physico-chemical and biological must be considered to ensure a sustainable aquaculture development in Nigeria (Adikwu, 1999). In order to achieve one of the millennium development goals of eradication of extreme poverty and hunger, a twin track approach of government participation with private smallholder commercial aquaculture development must be encouraged. This could be enhanced through the collation and dissemination of already existing research results as well as initiating research into emerging technologies in the field of aquaculture. This would ensure that project failures are kept to a minimum thus encouraging new entrants (especially small-holder individual and corporate bodies) into aquaculture. This is because project design and conceptions would be based on solid economics and technical facts not wishful over-enthusiastic projections. Recirculating Aquaculture System (RAS) is a fish production technique that ensures land and water resource control, reduction of input requirements and overall production cost while offering substantial harvest, among other advantages. RAS is a system in which some of the culture water is replaced intermittently or continuously, while part of the fluid is recirculated through settling basins and biofilters. It is an emerging technology in the field of aquaculture that has grown from mere experimental stage into maturity and commercial application in Europe and America (Akinwole, 2005). This system has drawn a lot of attention in Nigeria in recent years from current fish producers and those interested in becoming investors. Research efforts geared towards obtaining information on the economic and engineering aspects of recirculating systems would be worthwhile, in the long term and encourage aquaculture development in Nigeria. A sound and effective plan for the adoption of RAS could depend upon concise and logical appraisal of the few commercial installations that abound in the country with a view to identifying what could make (or what has made) them viable. This study investigated the economics and cost implication on the culture of the African catfish in RAS- based production facilities in Ibadan, Nigeria.

Materials and methods

Production costs analysis:

Three recirculating fish production facilities within Ibadan metropolis were monitored for twenty four months. These facilities were involved in the production of the three major growth phases of the African catfish namely; fingerlings, juveniles and adult fish. Data were obtained using structured questionnaires administered to supervisors of the farms to obtain production cost data. Based on the production cost data collected on the farm, the production costs analysis for the various systems in operation were computed using the procedures of Keenum and Waldrop (1988) and Dunning *et al.,*(1998). The procedure for production cost analysis was in line with generally recognized economic analysis format for recirculating aquaculture systems. The fixed costs include costs of system components: rearing tanks, biofilters, sedimentation tanks and overhead tank, depreciation on equipments mainly water pumps and electricity generators, and the depreciation on buildings. Part of the fixed cost component is the interest on initial investment. This includes total value of purchased land, building construction, labour and overhead costs. Depreciation for all cost parameters was taken on straight-line basis with zero salvage value. Life cycle of systems components were taken to be 10 years, 7 years for pumps and generators and 20 years for building. The interest rate on initial investment was 10% with a repayment period of 5 years.

Variable costs are costs that are directly related to production. These include costs for seed (fry, fingerlings or juveniles as the case may be) feed, energy (municipal electricity bills, fuel for generators), maintenance (office running cost; repairs on equipment), chemical (antibiotics, salt), labour wages and interest on variable cost. The interest on variable cost according to Dunning *et al.,* (1998) is necessitated because investment of funds in RAS means that the owner foregoes potential earnings from an alternative investment. Interest rate on variable cost was 10%, and is calculated on 50% of total operating cost in line with Keenum and Waldrop (1988) and Timmons (2000).

Profitability Index:

The Hasegawa index, as described by Rawlinson and Forster (2001), was used to investigate the profitability of each system. Hasegawa index (HI) is considered a convenient way to obtain an indication of profitability of an aquaculture venture. This index compares the ratio of the selling price and the price of feed to the ratio of the feed conversion rate (FCR) and the ratio of feed cost to total operating costs.

$$HI = \frac{a/b}{A/B}$$

Where,

HI - the Hasegawa index
a -feed conversion ratio
b -cost of feed to total operating cost
A - selling price of fish per kilo
B - the feed price per kilo
HI <1 indicate a profitable aquaculture venture.

Results and Discussion

The system characteristics of the recirculating systems of the African catfish production facilities are as shown in Table 1. RAS layout and process arrangement varies from one or three rearing tanks module for fingerlings and juvenile systems to four tank module for grow-out systems .Feeding operations varies in all the systems. The facilities utilize imported feed (e.g catco®,coppens®) to raise fish up to juvenile stage. The imported feed, they claimed are preferred in that they are water stable and are specifically made for recirculating systems. The use of these feeds, most (over 75% of respondent) operators said are needed to guide against too much mortality due to poor quality feed. At intervals during the course of this study, the water stability of these feeds, were put to test. It was observed that pellets remain stable in water for not less than two hours. It was also observed that a thin oily film forms on the water surface before the end of observation, which indicated that, the surface area of pellets are coated with oil which drastically slow down penetration of water into the pellet. Feed for grow-out fish in most farms are compounded pelleted local feed. Water flow rate through fish rearing tank varies for different growth stage and in the various farm. The hydraulic tank volume exchanges also differ. (Table 1). The water flow rate in fish rearing tank also varies. The ranges recorded are 1 – 2 l/min in fingerling systems, 2 – 6 l/min for juveniles and 6 – 20l/min for grow-out systems. Water treatment components differ for each culture stage and from one facility to another. This configuration and characteristics varies depending on the number of rearing tanks served. Biological performance and growth production figures of the African catfish *Clarias gariepinus* cultured in these facilities are reported by Akinwole and Faturoti (2007).The average culture duration are 28, 30 and 154 days respectively for the fingerlings, juveniles and grow-out systems. With allowance for system clean-up and preparation for the next cycle after a complete culture-harvest cycle. This in most cases takes between 14, 26 and 30 days for the fingerlings, juveniles and grow-out systems respectively. The culture cycle duration for the three systems thus averaged 42, 56 and 184 days respectively. The number of complete culture cycle monitored for each of the facilities and for which the average production costs characteristics are evaluated are 15, 14 and 4 for the fingerlings, juveniles and grow-out systems respectively (Table 1).The production costs associated with the culture of *Clarias gariepinus* as obtained in the facilities under study are as shown in Tables 2 to 4.

Table 1: System Characteristics of RAS Facilities evaluated for the culture of the three growth phases of the African Catfish

	Fingerlings System	Juvenile System	Grow-out System
No. of RAS Modules	3	6	5
No. of Rearing tank per module	3	1	4
Volume of each Rearing tank, m^3	0.84	1.30	16.8
Rearing tank volume exchange (minute)	186	236	1083
Rearing tank material (rectangular shape)	PVC	PVC	Reinforced Concrete
Sedimentation tank (rectangular shape)	0.93 m^3, Concrete, polypropylene media	0.93 m^3, Concrete, polypropylene media	6 m^3; Concrete, plastic crate with gravel stones
Biofilter (volume,media,type)	0.93 m^3, polypropylene media, Trickling	0.93 m^3, polypropylene media, Trickling	8.2 m^3; Polypropylene media; Trickling
Average stocking density, fish/ m^3	22,700	9230	150 – 250
Number of feeding per day	15	12	6
Feeding rate (%BW)	3	8	4.0
% CP in feed.	45	45	40
Number of culture cycles monitored	15	14	4

The cost figures are based on location – specific conditions at the facilities' environs and are representative of the economic state as at March 2012. The number of days per production cycle is the actual number of days from stocking to harvesting and system clean up after harvest.

For each culture system, the figure represents the average cost characteristics as experienced during the period of study. Average production cost range from ₦ 5.40, ₦ 18.49 and ₦ 209 for one fingerling, juvenile and adult African catfish respectively. In all cases, variable cost accounts for more than 75% of total cost. Within fixed costs input, interest payment on initial investment ranks the highest. While feed cost accounts for the highest among variable costs for fingerlings and grow – out systems, seed cost is highest for juvenile production system. The reason for this may be due to the fact that survival at fry – fingerlings stage, which serves as seed for juvenile culture, is relatively low, thereby raising the production cost per fingerling.

The Hasegawa index (HI) for fingerlings and grow – out production ventures are 1.30 and 1.13 respectively. This indicates that both ventures are not profitable. Juvenile production system with hasegawa index of 0.55 is the only profitable venture amongst the three. The index are computed with farm gate selling price per kilogram of fish at ₦ 2,381.00, ₦ 2,232.00 and ₦ 260.00 for fingerling, juvenile and adult fish respectively (Table 5). The selling price for advanced fingerling (4.2g) and juvenile (11.2g) of the African catfish were fixed at the rate of ₦ 10.00 and ₦ 25.00 respectively. The reason for the non-profitable status of fingerling and adult/grow out fish production systems is not far-fetched. The feed cost per kg for fingerling is ₦ 1,829.00 being totally imported. To make the system break even, it would require provision of the same quality feed at a reduced cost, as low as ₦ 1,400.00 by which time Hasegawa index will be 1.00, the break-even point. The feed conversion ratio for the grow- out system is above1.0, the generally proposed ideal FCR for recirculating aquaculture systems. The utilization of given feed by fish is very low, with most ending as waste. Improving the FCR to 1.00 or an increase in the selling price to ₦ 300.00 per kg will bring the HI index to just below 1, signifying marginal profitability for the ventures. In the culture systems (fingerlings and grow-out facilities) found not to be profitable, feed cost account for the highest proportion of operating cost, 38.80 % and 43.19% respectively (Tables 2 and 4). This indicated that, reducing feeding cost in terms provision of cost effective feed may be a major production cost consideration in recirculating aquaculture system for African catfish production. For these two culture systems with HI greater than 1, the two possible extremes in fish feed consideration were experienced. In the fingerling production system, the FCR was less than 1, indicating good feed utilization but the cost of feed is very high. The imported feed used cost ₦ 1,829.00 per kg. This increased the operating cost tremendously. Added to this is the low survival rate also experienced. The combined effect thus caused the venture to perform low on the profitability scale. The unit cost of feed is relatively cheap in the grow-out facility but the feed is not well utilized as evident in the high FCR. A greater part of the administered feed ends up as wastes contributing to poor quality in culture water. This created additional problems by causing stress to the fish, which further limits growth. FCR has an important input in running cost of recirculating aquaculture systems. For the grow – out system, feed cost accounts for 43% of the total cost at FCR of 1.148 indicating that more feed is required to achieve weight gain. Rawlinson and Forster (2001) reported that high FCR may be due to poor feed quality, poor feeding regime, poor water quality among others. Operating conditions for the grow – out system under review is beset with these highlighted problems, the feed is not water stable, feeding regime is poor as fish are fed the entire daily ration in just five installments. These two problems combined to give poor quality to the recirculated culture water.

Table 2: Production* cost Characteristics associated with culture of African Catfish Fingerlings in Recirculating system.

Cost Parameters	=N=/cycle	%Total
Variable Cost		
Seed	72000	13.48
Feed	201200	38.80
Energy	77250	14.90
Maintenance	18000	3.47
Chemicals	7000	1.35
Labour	59230	11.42
Interest on Variable Cost	2501	0.48
Sub-Total(Variable Cost)	437181	84.30
Fixed Cost		
System Components	4384	0.85
Depreciation on Equipments	7411	1.43
Depreciation on Building	8313	1.60
Interest on Initial Investment	61292	11.82
Sub-Total (Fixed Cost)	81400	15.70
Total Cost	518581	100
Production Cost per fish	5.40	
Hasegawa Index	1.303	

*Summary:

Days /production cycle: 42 | Number of cycle/year: 8.7
Survival rate: 80.06% | Average fish no. harvested /cycle: 96072
FCR: 0. 78 | Average weight per fish = 4.2g

Table 3: Production*Cost Characteristics associated with culture of African Catfish Juveniles in Recirculating system

Cost Parameter	=N=/cycle	%Total
Variable Cost		
Seed	504000	48.77
Feed	342344	33.12
Energy	31551	3.05
Maintenance	7847	0.71
Chemicals	17500	1.69
Labour	51046	4.94
Interest on Variable Cost	7317	0.71
Sub-Total (Variable Cost)	961605	93.04
Fixed Cost		
System Components	9121	0.88
Depreciation on Equipments	9422	0.91
Depreciation on Building	11083	1.07
Interest on Initial Investment	42270	4.09
Sub-Total (Fixed Cost)	71896	6.96
Total Cost	1033501	100
Production Cost per fish	18.49	
Hasegawa Index	0.55	

*Summary:

Days /production cycle: 56 — Number of cycle/year: 6

Survival rate: 93.1% — Average fish no. harvested /cycle: 55860

FCR: 1.005 — Average weight per fish = 11.2g

Table 4: Production*Cost Characteristics associated with culture of table sized African Catfish in Recirculating system

Cost Parameter	=N=/cycle	%Total
Variable Cost		
Seed	294000	11.85
Feed	1071521	43.19
Energy	158352	6.38
Maintenance	52988	2.14
Chemicals	31893	1.29
Labour	208426	8.40
Interest on Variable Cost	90859	3.66
Sub-Total (Variable Cost)	1908039	76.92
Fixed Cost		
System Components	101074	4.07
Depreciation on Equipments	81512	3.29
Depreciation on Building	42422	1.71
Interest on Initial Investment	347630	14.01
Sub-Total (Fixed Cost)	572638	23.08
Total Cost	2480677	100
Production Cost per kg.fish	209	
Hasegawa Index	1.131	

* Summary:

Days /production cycle: 184 Number of cycle/year: 1.98

Survival rate: 86.5% Average fish no. harvested /cycle: 12110

FCR: 1.148 Average weight/fish: 981g

Table 5: Values of the Hasegawa Index Computation Parameters

Index Parameters	Venture types: Fingerlings System	Juvenile System	Grow- Out System
A	0.78	1.005	1.148
b	0.46 {i.e. 201200 / 437181}	0.356{i.e. 342344 / 961105}	0.562{i.e.1071521 / 1908039
Ratio a/b	1.696	2.823	2.043
A (₦)	2381	2232	260
B (₦)	1829	438	144
Ratio A/B	1.302	5.096	1.806
Computed HI	1.303	0.554	1.131

Where,
HI - the Hasegawa index
a - feed conversion ratio
b - cost of feed to total operating cost
A - selling price of fish per kilo
B - the feed price per kilo
Note;
Farm gate selling price for *Clarias gariepinus* were fixed as ₦ 10.00 per fingerling; ₦ 25.00 per Juvenile and ₦260.00 per kilo for Table size.

The problems identified bring to the fore, the importance of well-balanced water stable feed formulation in RAS, appropriate in composition for the culture species. Interventions to system operation such that will cause a decrease in the HI would enhance the profitability of the venture. This could be done by either decreasing numerator (of the HI equation) by improving FCR or by increasing the denominator by increasing the selling price or reducing cost of feeding. Sensitivity analysis showed that changes in selling price and FCR affects the HI for the grow – out system. HI varies from 1.13 at selling price of ₦260.00/kg to 0.74 at ₦400.00/kg of fish. With the profitability rating of the fingerling and grow – out systems, one might wonder why the farms are still in operation? Both farms are engaged in the culture of more than one growth stage of African catfish. Infact, both are also involved in juvenile culture. The profitability status of the juvenile system thus seems to provide a complementary trade- off for the economic loss of the other systems.

Conclusion

Operating cost represents the highest production cost component in commercial fish production with RAS. Capital prudence by investors in RAS by ensuring sufficient operating cash flow may serve as an antidote against failure or system abandonment due to under-capitalization. The major bio-economic variables that influences profitability of commercial recirculating fish production facilities include survival rate, growth rate, feed conversion ratio and species market attributes in terms of product acceptance and price.

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