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OPERATIONAL CHARACTERISTICS AND FINANCIAL PERFORMANCE OF AFRICAN CATFISH HATCHERIES UNDER DIFFERENT MANAGEMENT SYSTEMS IN IBADAN, NIGERIA

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ABSTRACT

Operational characteristics as influenced by management systems are crucial to the sustainability of fish seed production industry. However, there is a dearth of technical information on the characteristics and financial performance of most fish hatcheries in Nigeria. There is, therefore, a need to provide this information to properly guide existing operators and the will-be investors on operational features that will ensure sustainability of fish seed production in Nigeria. The study was, therefore, carried out to compare and understand the performance of different fish seed production management systems in Ibadan, Nigeria. A survey of 51 registered and operational hatcheries employing flow-through (FL), recirculating cum flow-through (RCFL) and recirculating systems (RC), in the eleven Local government areas of Ibadan metropolis was carried out between April and May, 2017. Technical information was sourced using structured questionnaire. Data was analysed using descriptive statistics and one-way ANOVA with means separated using Duncan Multiple Range Test. The study showed that the average African Catfish hatchery production was 4.90 million seed per year as computed from the mean from the three systems (2.29 million, 2.63 million and 9.79 million for RC, RCFL and FL systems, respectively). On average, 64.6% of hatchery production was sold as fingerlings (5cm), while 35.4% of seed production was sold as juveniles (8 -15cm). Total costs and total revenues in FL hatcheries (N21.38 million and N86.09 million, respectively) were highest and least values (N5.62 million and N22.72 million, respectively) were recorded in RC hatcheries. Net profits were significantly higher in FL systems (79.6% of sales) and RC systems (79.2% of sales), than RCFL (67.7% of sales) and. A 50% reduction in seed price and 75% increase in operating costs resulted in losses only in RCFL system. Main challenges of hatchery operation were price fluctuation, a high cost of power and availability of high-quality broodstock, among other factors. Flow-through culture system is mostly adopted in Ibadan, South-western Nigeria and gave the highest net profit as a percentage of sales, but profit was marginally higher than the result from the recirculating system.

Key words: Hatcheries, Catfish, Seed, Profit, Culture systems, Operational features, Technical information, Ibadan

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INTRODUCTION

Inadequate fish seed supply has been identified as a major constraint to aquaculture development in Nigeria [1]. Desired quantity and quality of fish seed have never been available. While the present total production and supply from all sources are less than 50 million fingerlings, the requirement in the short term is at least 500 million, annually. Quality fish seed is an essential component for aquaculture growth and in promoting seed supply. It should be considered that small localized hatcheries whilst delivering seed locally, can be more responsive to changing trends in demand, as they are economically flexible and the start-up costs are lower. Therefore, they can play a major role in the sustainable supply of fish seed and, in many cases, may be more appropriate media for seed distribution when compared with larger and centralized seed supply systems [2].

Management issues including broodstock could impact negatively on production if not properly handled. For example, the potential negative impact of genetics, such as inbreeding, genetic drift, introgressive hybridization, and unconscious selection, has been identified in many hatchery operations [2]. These impacts on the income generation from fish seed production. There is also variation in seasonal weather conditions which impact on fish seed production to a great extent. While summer temperatures are suitable for growth and reproduction of the main farmed species, *Clarias gariepinus,* temperatures during cold season fall below optimal levels for its growth and propagation (20-30^{o}C). It is, therefore, imperative to have a clear understanding of the technical and financial performance of hatcheries for increased production, more income generation and to encourage more investors.

Ibadan is the third most populous city in Nigeria (after Lagos and Kano), with a sizeable number of fish farmers. It has been identified by the Federal Department of Fisheries as one of the major centres for African catfish seed production in Nigeria [1], with production described to be in the rational stage [3]. This study examines the operational characteristics and economic performance of hatcheries under different systems of management within the eleven local government areas in Ibadan metropolis and proffers appropriate recommendations on the improvement of seed production.

MATERIALS AND METHODS

Study area

Ibadan, the largest indigenous city in West Africa [4] located on latitude 7^{o}23’47’’N and longitude 3^{o}55’0’’E covers a total land area of 3123km^2 with 11 local governments, has a population density of 586 persons per km^2 [5]. Ibadan has a tropical wet and dry climate with a lengthy wet season and relatively constant temperatures throughout the course of the year. The wet season runs from March through October. November to February forms the city’s dry season, during which Ibadan experiences the typical West African harmattan. The city is home to several small, medium and large-scale fish farm that thrive using the earthen ponds system to culture fish. So many catfish hatcheries, therefore, exist to service the fish seed needs of these farms.

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Sampling technique

A sampling frame consisting of all farm location and status was gotten from the Oyo State **(Figure 1)** Department of Fisheries (SDF), Ministry of Agriculture. A total-sampling of the 51 active fish hatcheries was conducted with the aid of a structured questionnaire between April and May, 2017. Information including management practices, hatchability rates, and socioeconomic data were obtained. Production records were obtained from farmers with records and validated with records from the SDF.

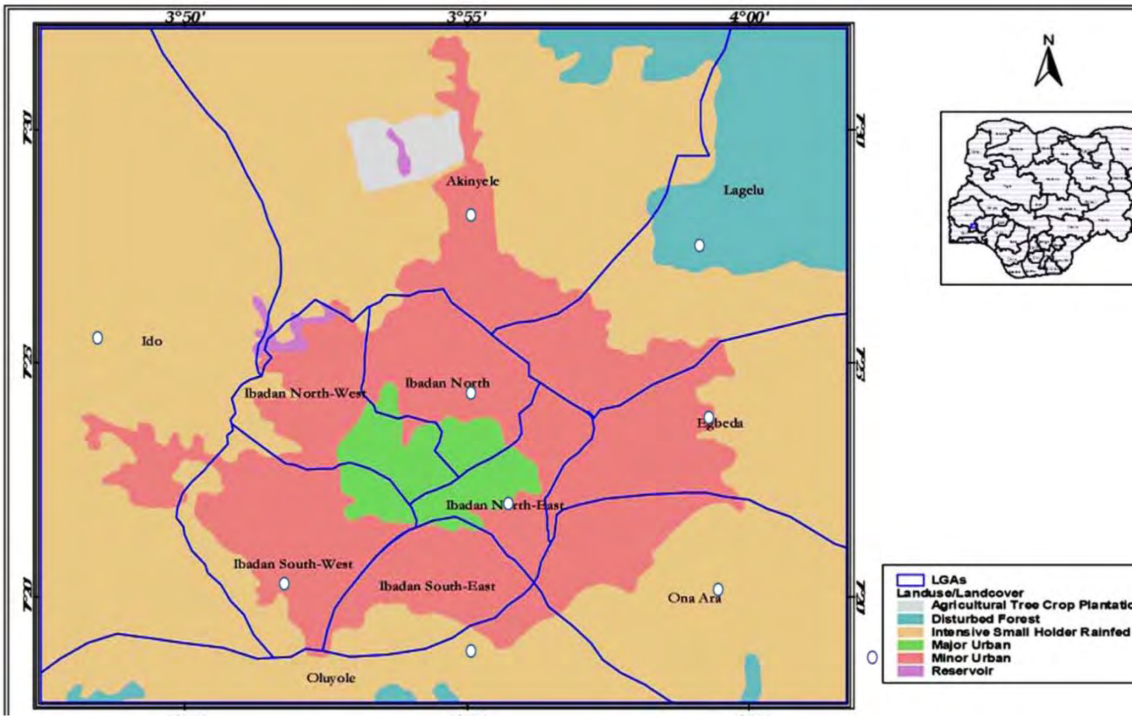

Figure 1: Map of Ibadan showing the different local government areas
Source: Fourchard [6]

Analytical technique

Descriptive statistics comprising of frequency distribution, mean and percentage were used to summarize the socio-economic characteristics of farmers. One-way ANOVA was also used to compare data across hatchery systems while Duncan's Multiple Range Test was used to separate means.

The financial performance of the hatchery systems was compared by developing a cost and income table [7, 8]. The main indicator of financial performance was Net Hatchery Income (NHI) expressed as:

$$NHI = GR - TC$$

Where;

$$TC = TVC + TFC = PxX$$

$Px = Unit\ Price\ of\ input, X = Quantity\ of\ input, GR = PyY,$
$GR = Gross\ return, Py = Unit\ price\ of\ output, Y = Quantity\ of\ output,$
$TC = Total\ cost\ (N), TFC = Total\ fixed\ cost\ (N) and\ TVC = Total\ variable\ cost.$

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Calculation of depreciation costs of equipment was computed using the straight-line method [9] and salvage value for all equipment was assumed to be zero [10]. Value added was calculated according to Macfadyen *et al*. [11].

RESULTS AND DISCUSSION

This present study revealed that all the fish hatcheries surveyed specialise in catfish fingerlings and juveniles productions. Of all the hatcheries sampled, only 2% were owned by the government, 29.4% were rented/ leased and 68.6% were owned by private farmers (Table 1). Also, 80% of the farmers operate indoor hatcheries while 20% operated both indoor and outdoor hatcheries. Most of the farms (68.6%) came into operation less than 10 years ago, while 21.6% were established in the past 11-15 years, with less than 10% in existence over twenty years ago. This study shows the increased establishment of catfish hatcheries in the last ten years, as close to 70% of the total number of hatcheries were started within this period. Most catfish seed producers operate on privately owned land with government ownership being highly insignificant. This attests to the major role of government in providing enabling operational environment for investors in Nigeria [12].

Catfish seed producers' source broodstock more from grow-out farmers, as only 3.9% produced broodstock on farm, 70.6% sourced entirely from other farmers while 25.5% combine farm-raised and sourcing from other producers (Table 2). The size of broodstock used in seed production has been considered a major factor in determining the success or otherwise of a breeding exercise [13]. From this present study, 13.7% of farmers use broodstock of average sizes 0.9-1kg, 58.8% use broodstock of size 1-2kg, while 27.5% use fish above 2kg. The choice of broodstock with an average weight of 1-2kg, and the results obtained from the three culture systems, deviates from the earlier recommendation of 300-800g by Graaf and Janssen [14], where ease of handling was a major factor in their assertion. However, recent reports have shown that increased weight of female brooders increased hatching success, though the weight of a male is reported not to be correlated to either fertility or hatchability [15, 16]. Broodstock are stocked in spawning units at an average density of 8.7 fish per m^2 and the reported sex ratio of 3 females to 1 male which were the same in all three systems, supported efficient seed production. Bhujel [13] reported that high broodstock stocking densities could have a negative effect on seed production, also concluding that biomass weight or the relative sizes of male and female fish are more important than the sex ratio.

In addition, observation made from the use of broodstock does not show any significant difference among the various management systems, both for farms that have operated for a long time and those newly established. This point to the fact that experience of a farmer may not influence the performance of broodstock.

The average land area used in operations was 1.7ha, and size increased with the use of two culture systems (Table 3). The table showed that most of the parameters measured were significantly different ($p<0.05$) among the three production systems except for the number of cycles per year and the batch days of each production cycle. This study

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revealed that 82% of hatcheries visited practiced indoor hatchery while 18% were engaged in both indoor and outdoor hatcheries. Indoor hatcheries allow higher stocking densities, improved feeding and most importantly, control of water exchange for optimal condition which consequently improve system productivity [17].

Average yearly seed production was highest in FL systems (9.79 million) and least in RC (2.28 million). These figures correspond with the number of females held in each culture systems, as more females were stocked in FL than the other culture systems. The number of production cycles and spawning months per annum were more in RC (11.96 and 9.56, respectively) and least in RCFL (9.56 and 7.78, respectively). Hatcheries with greater control over water temperatures were able to complete more spawning cycles per year and have shorter intervals between collections of spawning batches.

The cost (fixed and variable) of production for the different culture systems is presented in Table 4. Variable costs accounted for 86.7, 77.8 and 82.9% of total costs in FL, RCFL, and RC respectively. The 37% of variable costs spent on fish feed, and 28% for staff salaries and wages reported in this study are in agreement with the reports in Eldokia *et al*. [18] and Naei *et al.* [8]. The cost for salaries and wages in this present study is, however lower than 48% of labour costs reported in a study on hapa-based tilapia hatcheries in Thailand [19]. Fixed costs averaged 17.1% of total costs, but the proportion varied between systems. Similar results were reported by Ahmed *et al*. [20] who found that fixed costs represented 19.6% of total costs, although lower than the 29% and 32-35% fixed costs reported by Eldokia *et al.* [18] and Bhujel *et al.* [19], respectively.

Cost of medication is lowest in FL system (0.01 million) compared to 0.03 million and 0.02 million recorded in RCFL and RC, respectively. This may be attributed to the continuous removal of nitrogenous waste in FL system, thus keeping water quality optimal. This is at variance with the RC system, where suspended solids and nitrogenous wastes are mechanically trapped and routine flushing is required to remove sludge.

The fixed costs per unit of Catfish seed production were highest in RCFL systems (average ₦0.22 million per million Catfish seed produced in a hatchery per year) followed by RC systems (₦0.18 million per million Catfish seed produced in a hatchery per year) and FL systems (₦0.08 million per million Catfish seed produced in a hatchery per year). The highest average fixed costs were for depreciation of equipment and land rent also previously reported by Ahmed *et al.* [20]. This study found that fixed costs per unit of Catfish seed production were highest in RCFL systems followed by RC with the least recorded in FL systems.

The results of sales of fish seed show that fingerlings are preferred as it accounts for 65.9% of sales compared to 34.1% recorded for juveniles. The most common selling size of catfish fingerlings is 7-10g while juveniles are sold in the size range of 15-20g after rearing for about 55-65 days in nursery ponds. The study revealed that the mean revenue from fingerlings sales was higher in FL systems than RCFL and RC systems.

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Average hatchery revenue was ₦3.07 million, ₦3.06 million and ₦3.86 million per hatchery per year in FL, RCFL and RC systems respectively (Table 5). Statistically, many of the results such as average fingerlings and juvenile production trends, gross revenue, fingerlings sales revenue, total variable costs, return on investment income above TVC and percentage operational profit indicate similar trends between the RCFL and RC, while they were significantly different ($p<0.05$) from the values from the FL system. However, the average total output from each system was significantly different among the systems. Both variable and fixed costs increased with increasing levels of technological inputs in the following order - FL, RCFL, and RC systems. Gross return and income above variable cost were higher in FL systems. Average operational profits as a percentage of sales were 84%, 82.3% and 74.9% for RC, FL and RCFL systems, respectively. The net profit as a percentage of sales in RCFL was the lowest at 67.7% and highest in FL system at 79.6% of sales.

Sensitivity analysis was performed to measure the financial performance of the three Catfish hatchery systems in the case of increasing operating costs and decreasing seed prices (Table 6). Analysis showed that the three hatchery systems would still generate positive net returns even if seed prices decrease by 20% and variable costs increased by 20%. However, when seed prices were 30% less than the current levels and operating costs were increased by 30%, only FL systems could still generate profits.

Increasing the productivity and profitability from any of the three systems in Nigeria would require addressing major challenges of fluctuating prices of fingerlings and juveniles, limited availability of water, high cost of power, quality of broodstock, lack of technical support for fish health management and insufficient skilled workers in breeding as enumerated in Omonona and Ajani [12]. This is in addition to high cost of investment, poor marketing channels, lack of finance and poor genetics of broodstock Omitoyin *et al.* [21] and Ajani *et al.* [22].

CONCLUSION

There is a significant increase in Catfish farming within the study area within the last decade, with more hatcheries operating under private ownership. Most farmers utilise flow-through system of production, while just few use the recirculating system, and the average yearly seed production is highest in the former. Although more spawning cycles can be obtained in the recirculating system (because of the possible control over temperature within the system), mean revenue for fish seed sales is higher in flow-through system.

In order to tap into the advantages of using the recirculating system of culture (higher stocking density, resource conservation and optimal space utilisation) and increased and more profitable production from the flow-through system, there is the urgent need for government intervention in the establishment of aquaculture villages. This will bring forth benefits associated with economies of scale as resources (power, quality water, fish health management and quality broodstock) will be shared and adequately managed for increased production.

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Table 1: Distribution of hatchery ownership within Ibadan

Characteristics	Frequency	Percent
Land tenure system		
Private	35	68.6
Government	1	2.0
Rented/leased/borrowed	15	29.4
Total	51	100.0
Types of hatchery		
Indoor	41	80
Outdoor	10	20
Total	51	100
Years of experience		
0-10 years	35	68.6
11-15 years	11	21.6
>20 years	05	9.8

Table 2: Source of broodstock and weight preferred for spawning

Source of broodstocks	Frequency	Percentage
Farm-raised	2	3.9
Purchased	36	70.6
Farm-raised and purchased	13	25.5
Total	51	100.0
Weight of broodstock		
0.6-1.0kg	7	13.7
1.0-2.0kg	30	58.8
2.0-3.0kg	14	27.5
Total	51	100

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Table 3: Summary of operational characteristics of African Catfish hatcheries using different production systems (Mean ± SEM)

Characteristic	FL	RCFL	RC	ALL
Average hatchery size (ha)	2.08±0.00[a]	1.95±0.00[c]	1.10±0.00[b]	1.71±0.15
No. of earthen ponds	205.33±0.33[b]	237.66±0.66[a]	55.0±0.57[c]	166.0±28.14
Average production per year (million)	9.79±0.00[a]	2.63±0.00[b]	2.28±0.00[c]	4.90±0.00
Number of broodstock	1285±1.66[a]	373±1.85[b]	238±0.57[c]	631±164.67
Number of females	1261±1.00[a]	347±0.66[b]	213±0.57[c]	607±164.10
Number of males	24.0±0.62[a]	24.0±0.64[a]	25.0±0.63[a]	24.0±0.50
Average size of females (g)	1250±2.89[b]	1750±2.88[a]	1150±0.33[c]	1383±92.7
Average size of male (g)	1200±0.66[c]	1450±2.88[a]	1300±0.66[b]	1317±36.24
Number of cycles per year	10.28±0.00[a]	9.56±0.00[a]	11.96±0.00[a]	10.6±0.35
Days between batches	28.06±0.00[a]	27.69±0.03[a]	29.96±0.00[a]	28.56±0.35
Spawning period (months)	8.23±0.03[a]	7.78±0.00[b]	9.56±0.08[a]	8.52±0.26
Seed production/female/yr.	22328±8934.71[a]	8184±6667.12[b]	8302±6632.78[b]	12938±6639.91

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Table 4: Production costs per million African Catfish seed produced in the three hatchery systems

Item	FL		RCFL		RC		Mean	
Variable costs (₦ million/million seed)								
	Value	%	Value	%	Value	%	Value	%
Brooder feed	0.62	2.90	0.30	3.04	0.13	2.31	0.35	2.85
Fry feed	1.85	8.65	0.90	9.11	0.39	6.94	1.05	8.54
Fingerling feed	2.45	11.46	1.20	12.15	0.52	9.25	1.39	11.39
Juvenile feed	3.08	14.41	1.50	15.18	0.65	11.57	1.74	14.16
Medication	0.01	0.47	0.03	0.30	0.02	0.36	0.05	0.41
Hormone	0.41	1.92	0.11	1.11	0.07	1.10	0.20	1.63
Lime	1.20	5.61	0.31	3.14	0.25	1.20	0.59	4.80
Salaries	5.81	27.17	2.76	27.94	1.60	28.47	3.39	27.58
Fuel & transport	0.70	3.27	0.14	1.42	0.13	2.31	0.32	2.60
Repairs & maintenance	0.2	1.08	0.05	0.51	0.04	0.71	0.11	0.90
Brooder replacement	1.4	6.55	0.29	2.94	0.27	4.80	0.65	5.29
Other expenses	0.69	3.23	0.10	1.01	0.26	4.63	0.35	2.85
Total variable costs	18.54	86.7	7.69	77.8	4.33	77.1	10.19	82.9
Fixed costs (₦ million/million seed production)								
Land rent	0.81	3 .79	0.85	8.60	0.39	6.94	0.68	5.53
Depreciation	2.03	9.49	1.34	13.56	0.90	16.01	1.42	11.56
Total fixed costs	2.84	13.3	2.19	22.2	1.29	22.9	2.10	17.1
Total costs (₦/million seed)	21.38	100	9.88	100	5.62	100	12.29	100

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Table 5: Catfish hatchery production, sales revenue and financial performance in the three systems

Item	FL	RCFL	RC	ALL
Average production(million)	9.79±1.05[a]	2.63±0.07[b]	2.29±0.07[c]	4.90±2.79
Fingerlings productn (mil.)	6.61±8271.08[a] (68%)	1.65±5279.94[b] (62.7%)	1.45±5702.38[b] (63.3%)	3.23 (65.9%)
Juveniles production (million)	3.18±3270.11[a] (32%)	0.98±2131.77[b] (37.3%)	0.84±5656.8[b] (36.7%)	1.67 (34.1%)
Average fingerling price (₦)	7.7±1.04[a]	8.0±1.28[a]	8.4±1.25[a]	8.03±1.12
Average juvenile price (₦)	16.9±1.68[a]	17.8±2.06[a]	17.7±1.38[a]	17.5±1.78
Fingerlings sales revenue (million₦)	50.89±9.25[a] (49%)	13.2±1.12[b] (43%)	12.18±1.06[b] (45%)	25.42 (45.6%)
Juvenile sales revenue(million₦)	53.74±7.80[a] (51.4%)	17.4±4.82[b] (56.9%)	14.87±1.21[b] (55%)	28.67 (54.4%)
Gross revenue (million₦/year)	104.63±8.82[a]	30.60±1.22[b]	27.05±1.02[b]	55.70±4.45
Total variable costs/hatchery(₦million)	18.54±1.96[a]	7.69±0.03[b]	4.33±0.01[bc]	10.19±0.02
Total fixed costs/hatchery(₦million)	2.84±2.54[a]	2.196±0.07[b]	1.29±4.04[c]	2.10±20.72
Total costs/hatchery(₦million)	21.38±8.9[a]	9.88±4.3[b]	5.62±2.9[c]	12.29±3.3
Gross return/hatchery/year(₦million)	104.63±1.34[a]	30.60±1.12[b]	27.05±1.89[b]	55.70±1.37
Income above TVC(₦million)	86.09±4.4[a]	22.91±2.7[b]	22.72±2.4[b]	43.91±3.32
Operational profit as% of sales	82.3[a]	74.9[b]	84.0[a]	80.4%
Net hatchery income(₦million)	83.25±5.6[a]	20.72±2.9[b]	21.43±1.3[b]	41.80±1.8
Net profit as % of sales	79.6%[a]	67.7%[b]	79.2%[a]	75%

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Table 6: Sensitivity analysis of changes in seed prices and variable costs on net hatchery incomes (million₦/year)

		Changes in operating costs			
System	Changes in seed prices	0	+25%	+50%	+75%
FL	0	83.25	77.91	72.56	67.22
RC	0	21.43	20.03	18.62	17.22
RCFL	0	20.72	18.25	15.78	13.31
FL	-25%	57.09	51.75	46.40	41.06
RC	-25%	14.67	13.26	11.86	10.45
RCFL	-25%	13.07	10.60	8.13	5.66
FL	-50%	30.94	25.59	20.25	14.90
RC	-50%	7.91	6.50	5.10	3.69
RCFL	-50%	5,42	2.95	0.48	-1.99
FL	-75%	4.78	-0.57	-5.91	-11.25
RC	-75%	1.14	-0.26	-1.66	-3.07
RCFL	-75%	-2.23	-4.70	-7.17	-9.64

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