

AQUACULTURE PRODUCTION PRACTICES IN ENUGU STATE OF NIGERIA

Victor O. Omeje^{*1}, Tobias O. Elias¹, Paul C. Animoke¹, Calistus C. Okolo¹ and Chuka Ezema²

¹Department of Veterinary Medicine and ²Department of Animal Health and Production, Faculty of Veterinary Medicine, University of Nigeria, Nsukka, Enugu State, Nigeria.

ABSTRACT

Assessment of the status of aquaculture production practices in Enugu State, South East Nigeria was carried out between October, 2019 and February, 2020 with the aim of evaluating the fish farming practices and the socio-economic characteristics of fish farmers in the State. Forty-five fish farms were selected for the study, five from each of the three Local Government Areas selected from each of the three agro-ecological zones of the State using stratified random sampling. A structured questionnaire designed and validated by statisticians using Cronbach alpha reliability test with a reliability coefficient of 0.85% and informal interviews were used to collect data which were analyzed using simple descriptive statistics and the students t-test. Most of the fish farmers were males (64.4%) and majority (42.2%) of them were aged 50 years and above and had tertiary education (46.7%). Most fish farmers (62.2%) earn less than ₦100,000 while some (8.9%) earn above ₦401,000 annual profits from fish farming activities. However, analysis there was no significant variation in the distribution of the socioeconomic characteristics of the fish farmers in the agro-ecological zones. The prevalent fish species cultured in the study area were Clarias species and their hybrid (71.1%). Majority of the fish farmers (42.2%) cultured their fish in concrete ponds with only 26.7% of the culture systems having up to 1000-5000 stocking density. The study also indicated that disease was one of the major factors militating against aquaculture development in the study area. However, only few of the farmers (17.8%) consulted veterinary professionals when they encounter diseases in their farms. The study concluded that aquaculture production in the study area is economically rewarding and profitable.

Keywords: Aquaculture; production, constraints, Enugu State, Nigeria.

INTRODUCTION

Aquaculture refers to the hatching and rearing of marine and freshwater aquatic animals aimed at maximizing their production mainly for consumption [1]. The need for aquaculture arose from decline in

supply from capture fisheries as a result of over fishing and habitat degradation. One way to bridge the gap between the reduced fish Production from capture fisheries and increasing world fish demand is through aquaculture [2]. Aquaculture is rapidly expanding throughout the world and this has a high potential for providing valuable protein in less developed countries [3]. In Nigeria, domestic fish production from aquaculture has been increasing steadily whereas artisanal (capture) fisheries have been decreasing over the years [4]. Available data show that fish production from aquaculture ranged from 21,700 metric tons in 1999 to more than 316,700 metric tons in the year 2015 [5]. Aquaculture, as a farming system, has contributed immensely to food security and alleviated poverty especially among the rural poor folks [6]. Food security is essential for health and is the foundation of a developed society [7]. As a result of the inherent benefits accruing from fish farming, the practice has increased enormously and country wide in Nigeria. However, the demand for fish in Nigeria is greater than the local production. Domestic fish production (in metric tons) from 2010 to 2015 has been virtually flat [8]; suggesting stagnant capture fisheries that can no longer sustain increasing harvesting. As the production from capture fisheries are dwindling, the world population is rising astronomically, reaching numbers as high as 7 billion people in 2018 [9]. These show that there are a lot of potential in aquaculture because the industrial and artisanal catches are declining. In spite of the overwhelming abundance of fish farming resources, Nigeria remains a very large importer of fish, reason being attributed to the subsistence nature of those engaged in fish farming. However, low adoption of aquaculture technologies and poor management practices by fish farmers impede fish production from culture fisheries in Nigeria. The fact that production from aquaculture is related to manageable inputs such as the control of the production processes that make aquaculture less susceptible to unpredictable natural influences than capture “hunting” fisheries.

The role of aquaculture in economic development is now widely accepted. There is a particular interest among States like Enugu that are land locked, or which have restricted access to wild fish resources to develop aquaculture probably due to the need to diversify rural production, provide alternative employment for rural people, produce more fish for local consumption and to increase opportunities of earning foreign exchange [10]. According to Brummett *et al.* [11], poverty eradication through aquaculture can only be feasible if farming activities are environment friendly, socially responsible and economically viable. Although fishery resources are known to play vital roles in national development, a lot of constraints militate against the achievement of rapid development of the fishery sub sector. Lack of capital to invest in fish farming, low level of education and lack of skills and assets such as land retard aquaculture development in rural areas [12]. Government policies such as the land use act especially land tenure system put serious limitation on the amount of land that is available for aquaculture. Similarly, the unavailability of fish farming equipment and other related services can be a major disruption in the production processes. A large number of farms have failed to attain profitability in one or more years because of major disruptions in the production processes [13].

Climate change is modifying fish distribution and the productivity of marine and fresh water species. This has impact on the sustainability of fisheries and aquaculture and the livelihood of the communities that depend on fisheries. Fish disease is a substantial source of loss in aquaculture industry impeding both economic and social development in many ways including directly through productions losses and increased operational costs and indirectly through cost to society (Social, welfare and environmental), adjustment in market share and increase in price due to lower supply [14].

Fish diseases also affect fish survival and growth rates resulting to poor yield (both in quality and quantity) and also livelihood of people involved in the culture production. For sustainable fish production through aquaculture to be realizable, it is imperative that measures which will curtail the risk of accidental introduction of pathogenic organisms are established. Presently, there is scarcity of information regarding fish farming enterprises in Enugu State. It is aimed that this study will provide the relevant information required for improving aquaculture production in the State. Therefore, the main Objectives of the study is to carry out a survey of fish farms in Enugu state Nigeria with emphasis on feeding, management,

constraints and prevalent diseases affecting fish farms. The Specific objectives are to find out the management practices carried out by fish farmers, major problems encountered by them and to identify the most prevalent diseases encountered by the fish farmers. This also includes determining the impact of veterinary services to fish farming enterprise in Enugu State. It is hoped that this will reveal the constraints militating against fish farming, prevalent diseases of the fishes, management practices carried out by different fish farmers and the profitability of the fish farming enterprise in Enugu State and may serve as a baseline data to other studies in the same or related topics.

MATERIALS AND METHODS

Study area

This study was carried out to assess the status of fish farming practices in Enugu State, Nigeria. Enugu State is located within the derived savanna zone, between latitude 4°21' and 7°5' N and longitude 6° and 10° E, where agriculture is the main traditional occupation of the people. Enugu State is one of the states located at the foot of the Udi plateau. The State shares borders with Abia and Imo States to the south, Ebonyi State to the east, Benue State to the northwest and Anambra State to the west. The principal cities in the state are Enugu, Nsukka, Agbani and Awgu with Enugu as the capital and largest urban centre and from which the state derived its name.

Data collection and sampling techniques

The primary data were collected with the aid of a structured questionnaire administered through personal interviews and observations to elicit information from 45 fish farmers drawn purposively from Enugu State, Nigeria. There are seventeen local government areas (LGAs) and three agro-ecological zones (Enugu North, Enugu East and Enugu West) in Enugu State. For this study, three LGAs were randomly selected from each of the three agro-ecological zones making a total of nine out of the seventeen LGAs in the State as shown in Table 1. Five fish farms were purposively chosen from each of the nine afore-selected LGAs; based on the farmers' willingness to allow access to their ponds, making a total 45 fish farms sampled. Delineation and identification of the study farms lasted for 2 months. A structured questionnaire titled "Survey of fish farming practices in Enugu State" designed and validated by experts using Cronbach alpha reliability test with a reliability coefficient of 0.85% and informal interviews were used for data collection. The questionnaire sought information on important areas of fish farming practices including types of fish farmed, fish species cultured and the pond system or type used for fish rearing. Other information sought by the questionnaire were the pond capacity, sources of fingerlings and brood stocks, type of fish feed used, number of times of feeding the fish, management practices adopted in fish farming, record keeping activities in the farm, record of fish mortality in the past 6 months, most frequently encountered fish diseases, how the diseases were treated and the outcome of such treatments, sources of information regarding fish disease treatment and control, consultation of veterinary services and the profitability of fish farming enterprise. The study was conducted between October 2019 and February, 2020.

Table 1: Enugu State agro-ecological zones and the Local Government Areas sampled.

Agro-ecological zone	Local Government Areas Sampled
Enugu East	Enugu East, Enugu North, Enugu South
Enugu North	Igbo-Eze North, Nsukka, Uzo-Uwani
Enugu West	Aninri, Orji River, Udi

Data Analysis

Data generated from the study were analyzed using Student's t-test and descriptive statistics with emphasis in absolute distribution and percentages and also profitability analysis techniques. Significant differences were accepted at ($P < 0.05$)

RESULTS

The results of the socio-economic characteristics of fish farmers in Enugu State are presented in Table 2. The results of the study indicated that 64.4% of the respondent fish farmers were males while females constituted 35.6%. Majority (42.2%) of the fish farmers were aged 50 years and above whereas only 11.1% were within the age range of 21-30 years. Most of the respondents were literate; majority of them (46.7%) had HND/BSc, followed by school certificate (22.2%) and PhD (8.9%) holders. Although 40% of the farmers had less than 5 years' experience in the business, most (60%) had farming experiences spread between 6 years and more than 16 years. However, analysis showed that there was no significant variation in the socioeconomic characteristics of the fish farmers among the agro-ecological zones.

The annual income earned from fish farming revealed that majority (64.4%) of the farmers earned less than ₦100,000 from the fish farming activities with only 8.9% of them earning above ₦401,000 annually from the fish farming business. The annual earnings of the other farmers were spread between ₦100,000 and ₦401,000.

Table 2: Socio-Economic characteristics of fish farmers in Enugu State (N=45)

Characteristics	Number (%) of respondents			
	Enugu East	Enugu North	Enugu West	Total
Gender				
Male	10 (66.7)	9 (60.0)	10 (66.7)	29 (64.4)
Female	5 (33.3)	6 (40.0)	5 (33.3)	16 (35.6)
Age				
21 – 30	1 (6.7)	2 (13.3)	2 (13.3)	5 (11.1)
31 – 40	4 (26.7)	4 (26.7)	3 (20.0)	11 (24.4)
41 – 50	5 (33.3)	3 (20.0)	2 (13.3)	10 (22.2)
> 50	5 (33.3)	6 (40.0)	8 (53.3)	19 (42.2)
Educational level				
FSLC	1 (6.7)	1 (6.7)	0	2 (4.4)
WASC/SSCE	2 (13.3)	3 (20.0)	2 (33.3)	3 (22.2)
OND/NCE	1 (6.7)	0	2 (13.3)	3 (6.7)
HND/BSC	8 (53.3)	6 (40.0)	7 (46.7)	21 (46.7)
MSC	3 (20.0)	0	1 (6.7)	4 (8.9)
PHD	1 (6.7)	2 (13.3)	2 (13.3)	5 (11.1)
Experience (years)				
< 5	5 (33.3)	7 (46.7)	6 (40.0)	18 (40.0)
6 – 10	3 (20.0)	5 (33.3)	3 (20.0)	11 (24.4)
11 – 15	2 (13.3)	2 (13.3)	5 (33.3)	9 (20.0)
≥ 16				
Annual (naira)				
< 100,000	5 (33.3)	14 (93.3)	9 (60.0)	28 (62.2)
101,000 – 200,000	6 (40.0)	1 (6.7)	1 (6.7)	8 (17.8)
201,000 – 300,000	1 (6.7)	0	0	1 (2.2)
301,000 – 400,000	2 (13.3)	0	2 (13.3)	4 (8.9)
≥ 401,000	1 (6.7)	0	3 (20.0)	4 (8.9)

According to Table 3, 71.11% of the fish farmers cultured *Clarias* species while other farmers cultured *Heterobranchus* species (4.44%), *Tilapia* (8.89%) and *Heteroclaris*; a hybrid or cross between *Heterobranchus* and *Clarias* species (15.56%).

Table 3: The dominant fish species cultured in Enugu State, Nigeria

Species cultured	Number (%) Respondents			
	Enugu East	Enugu North	Enugu West	Total
<i>Clarias</i> Species	11 (73.33)	9 (60)	12 (80)	32 (71.11)
<i>Heterobranchus</i> species	1 (6.67)	1 (6.67)	0	2 (4.44)
<i>Heteroclaris</i>	2 (13.33)	3 (20)	2 (13.3)	7 (15.56)
<i>Tilapia</i>	1 (6.67)	2 (13.33)	1 (6.67)	4 (8.89)

Table 4 revealed that majority of the fish farmers (68.9%) engaged in table size fish production while the others were involved in either brood stock (28.9%) or fingerling (26.7%) production.

Table 4: Type of fish farming enterprises engaged in by fish farmers in Enugu State

Product type	Number (%) Respondents			
	Enugu East	Enugu North	Enugu West	Total
Fingerling Production	6 (40.0)	3 (20.0)	3 (20.0)	12 (26.7)
Table fish production	12 (26.7)	9 (60.0)	10 (66.7)	31 (68.9)
Brood stock production	5 (33.3)	4 (26.7)	4 (26.7)	13 (28.9)

Table 5 shows that among the pond types used for fish culture in Enugu State, concrete type was most common (42.2%) followed respectively by tarpaulin (37.8%), plastic/fiberglass (28.9%) and earthen type (8.9%) ponds. On the other hand, none of the fish farmers in Enugu State used the wooden vat type of pond during the study period.

In terms of the pond capacity, 51.1% of the fish farmers in Enugu State stocked 100 – 1,000 fish while 46.7% and 26.7% respectively stocked less than 100 and 1,000 – 5,000 fish in their ponds (Table 5). On the other hand, none of the fish farmers in Enugu State had a stocking density above 5,000 fish.

Table 5: Pond type and their capacity used for fish culture system in Enugu State, Nigeria.

Pond Type	Number (%) Respondents			
	Enugu East	Enugu North	Enugu West	Total
Pond type				
Concrete Pond	9 (60.0)	10 (66.7)	10 (66.7)	19 (42.2)
Earthen Pond	1 (6.7)	2 (13.3)	1 (6.7)	4 (8.9)
Plastic/Fiber pond	3 (20.0)	5 (33.3)	5 (33.3)	13 (28.9)
Wooden Vat	0	0	0	0
Tarpaulin	7 (46.7)	10 (66.7)	10 (66.7)	17 (37.8)
Pond Capacity				
Less than 100 fish	8 (33.3)	5 (33.3)	8 (33.3)	21 (46.7)
100 – 1000	6 (40.0)	8 (33.3)	10 (66.7)	23 (51.1)
1000 – 5000	6 (40.0)	3 (20.0)	3 (20.0)	12 (26.7)
Above 5000	0	0	0	0

Table 6 indicated that most fish farmers in Enugu State sourced their fingerlings from either private hatchery (88.9%) or the wild from rivers/streams within their locality (13.3%). On the other hand, 22.2% of them sourced their fingerlings through middlemen without any record of their origin. The two fish farmers (13.3%) who sourced their fingerlings from the wild (rivers and streams in their locality) also acquired their brood stock (13.33%) from the same sources in Enugu West agricultural zone (Table 6). The other sources of brood stock for the fish farmers included other fish farmers (26.75) and middle men (22.2%).

Table 6: Sources fingerlings and brood stock for fish farmers in Enugu State, Nigeria.

Sources Fingerlings	Number (%) Respondent			
	Enugu East	Enugu North	Enugu West	Total
Fingerlings				
Private hatchery	12 (26.7)	15 (100)	13 (86.7)	40 (88.9)
Government hatchery	0	0	0	0
Middle Men	3 (20.0)	4 (26.7)	3 (20)	10 (22.2)
Rivers/stream (wild)	0	0	2 (13.33)	2 (13.33)
Brood Stock				
Fish farmers	7 (46.7)	1 (6.7)	4 (26.7)	12 (26.7)
River/stream	0	0	2 (13.33)	0
Middle men	1 (6.7)	6 (40.0)	3 (20.0)	10 (22.2)

Table 7 revealed that 97.8% of the fish farmers in Enugu State fed pelleted feed to their fish during the study period. This was followed by those that used animal waste (24.4%), local pelleted feed (17.8%) and crop wastes such as rice bran (11.1%). With regards to feeding frequency, 80% of the fish farmers fed their fish twice daily while others fed them once (6.7%) or thrice (13.3%) daily (Table 7).

Table 7: Feed types and feeding frequency in fish farms in Enugu State

	Number (%) Respondent			
	Enugu East	Enugu North	Enugu West	Total
Feed types				
Extruded pelleted feed	14 (93.3)	15 (100)	15 (100)	44 (97.8)
Local Pelleted feed	2 (13.3)	3 (20.0)	3 (20.0)	8 (17.8)
Animal waste	3 (20.0)	6 (40.0)	2 (13.3)	11 (24.4)
Crop waste like rice bran	1 (6.7)	2 (13.3)	2 (13.3)	5 (11.1)
Feeding frequency				
Three	3 (20.0)	2 (13.3)	1 (6.7)	6 (13.3)
Twice	14 (93.3)	13 (86.7)	9 (60)	36 (80)
Once	7 (46.7)	4 (26.7)	4 (26.7)	3 (6.7)

Table 8 shows that fish farmers in Enugu State used several management practices in their operations during the study period. Such management practices included periodic water change (93.3%), sorting of their fish (84.4%), checking of water parameters (78.3%) like pH, temperature and oxygen, covering their culture ponds with net (28.9%), weighing the fish periodically (28.9%) and giving drugs for treatment when necessary (53.3%). In terms of recording of farm activities, 51.1% of the farmers always kept records, 35.6% sometimes kept records while 13.33% never kept any records of farm activities (Table 8).

As demonstrated in Table 9, the dominant diseases encountered in fish farms in Enugu State during the study as confirmed by consulted veterinary and laboratory services were mostly bacterial diseases such as

hemorrhagic septicemias (48.9%), ich or white spot disease (Ichthyophthiriasis) (42.2%), fungal infection (e.g. Saprolegnia and Achyla) (31.1%) and parasitic infestation (e.g. leech/lice) (17.8%).

Table 8: Management practices adopted by fish farmers in Enugu State

Management Practice	Number (%) Respondent			
	Enugu East	Enugu North	Enugu West	Total
Periodic Water change	14 (93.3)	14 (93.3)	14 (93.3)	42 (93.3)
Sorting of fish	12 (80)	13 (86.7)	13 (86.7)	38 (84.4)
Give drugs for treatment	8 (53.3)	7 (46.7)	9 (60)	24 (53.3)
Cover pond with net	3 (20.0)	3 (20.0)	7 (46.7)	13 (28.9)
Take weight of fish periodically	7 (46.7)	2 (13.3)	4 (26.7)	13 (28.9)
Check water parameters	13 (86.7)	12 (80)	8 (33.3)	33 (73.3)
Record keeping of farm activities				
Always	9 (60.0)	7 (46.67)	7 (46.7)	23 (51.1)
Sometimes	6 (40.0)	5 (33.33)	5 (33.3)	16 (35.6)
Never	0	3 (20.0)	3 (20.0)	6 (13.3)

Table 9: Prevalent fish diseases recorded in Enugu State

Disease Type	Number (%) Respondent			
	Enugu East	Enugu North	Enugu West	Total
Bacterial	9 (60.0)	5 (33.3)	8 (53.3)	22 (48.9)
Ich or white spot disease	6 (40.0)	6 (40.0)	7 (46.7)	19 (42.2)
Parasitic diseases	1 (6.7)	2 (13.3)	5 (33.3)	8 (17.8)
Fungal infection	6 (40.0)	3 (20.0)	5 (33.3)	14 (31.1)

Mortalities were recorded among fingerlings, table fish and brood stock during the study (Table 10). In most cases, mortalities were less than 50 fish among the fingerlings (55.6%), table fish (15.5%) and brood stock (6.7%). However, the mortality was generally higher among fingerlings than either the table fish or brood stock.

Table 11 shows treatment options used by fish farmers in Enugu State during outbreaks of diseases in their farms. Most of the fish farmers employed self-medication (40.0%) by purchasing drugs on their own to treat perceived infections in their farms. Only 35.6% and 17.8% of the farmers respectively consulted animal health personnel and veterinary doctors for such infections while 6.7% did not give any form of medication when there are infections in their farms (Table 11).

In most cases, the treatments instituted against diseases in their farms were either very effective (42.2%) or moderately effective (42.2%) whereas none of the respondent farmers reported that the treatment was ineffective (Table 12).

Regarding information on aquaculture practice, majority (64.4%) of the respondents got their information on fish disease treatment and control from personal experience, 51.1% sourced their information from friends/fellow fish farmers, 20.0% from WhatsApp group, 15.6% respectively from fish farmers meeting and Animal health personnel. Other sources included 13.3% from mobile phone (SMS and calls), 11.1% from research institutions and 6.7% from veterinary officers while 4.4% sourced from internet as shown in Table 13.

Table 10: Fish mortality recorded during the study (October and February)

Mortality	Number (%) respondent			
	Enugu East	Enugu North	Enugu West	Total
Fingerlings				
< 50	9 (60.0)	10 (66.7)	6 (40.0)	25 (55.6)
51 – 100	1 (6.7)	1 (6.7)	3 (20.0)	4 (8.9)
101 – 200	3 (20.0)	0	2 (13.3)	5 (11.1)
201 – 300	0	1 (6.7)	1 (6.7)	2 (4.4)
> 300	0	1 (6.7)	1 (6.7)	2 (4.4)
Table fish				
< 10	3 (20.0)	2 (13.3)	3 (20.0)	7 (15.5)
11 – 20	1 (6.7)	1 (6.7)	0	2 (4.4)
21 – 30	1 (6.7)	0	0	1 (2.2)
31 – 40	1 (6.7)	0	0	0
> 40	1 (6.7)	0	0	0
Brood stock				
< 10	1 (6.7)	2 (13.3)	0	3 (6.7)
11 – 20	0	1 (6.7)	0	1 (2.2)
21 – 30	0	0	0	0
31 – 40	0	0	0	0
41 – 50	0	0	0	0
> 50	0	0	0	0

Table 11: Treatment options for disease outbreaks by fish farmers in Enugu State

Treatment option	Number (%) of respondents			
	Enugu East	Enugu North	Enugu West	Total
Veterinary Doctors	4 (26.7)	2 (13.3)	2 (13.3)	8 (17.8)
Animal Health personnel	5 (33.3)	8 (53.3)	3 (20.0)	16 (35.0)
Self-Medication	6 (40.0)	4 (26.7)	8 (53.3)	18 (40.0)
No medication given	0	1 (6.7)	2 (13.3)	3 (6.7)

Table 12: Outcome of treatment Instituted

Treatment	Number (%) Respondent			
	Enugu East	Enugu North	Enugu West	Total
Very Effective	6 (40.0)	7 (46.7)	7 (46.7)	19 (42.2)
Moderately effective	9 (60.0)	4 (26.7)	6 (40.0)	19 (42.2)
Ineffective	0	0	0	0

Table 13: Sources of information on fish disease treatment and control in Enugu State.

Information Source	Number (%) Respondent			
	Enugu East	Enugu North	Enugu West	Total
Personal experience	11 (73.3)	7 (46.7)	11 (73.3)	29 (64.4)
Fellow fish farmers	11 (73.3)	3 (20.0)	9 (60.0)	23 (51.1)
Input dealers/chemists	0	0	0	0
Fish farmers meeting	5 (33.3)	0	2 (13.3)	7 (15.6)
Research Institution	0	2 (13.3)	3 (20.0)	5 (11.1)
Veterinary officers	1 (6.7)	2 (13.3)	0	3 (6.7)
Animal health personnel	1 (6.7)	5 (33.3)	2 (13.3)	7 (15.6)
Mobile phone (SMS, calls)	1 (6.7)	5 (33.3)	0	6 (13.3)
WhatsApp group	3 (20.0)	1 (6.7)	5 (33.3)	9 (20.0)
Internet	1 (6.7)	1 (6.7)	0	2 (13.3)

DISCUSSION

The results of this study have shown that males rather than females dominated fish farming business in Enugu State probably because ownership of land for farming purposes does not favour the female folks. Generally, in Igbo culture, the man is usually the bread winner for the family and women face discrimination in land inheritance and ownership rights [15]. Land is a key factor in agricultural activities including the establishment of fish farms and is an increasingly scarce and expensive commodity especially in urban areas. Most of the fish farmers were aged 50 years and above while just a few of them were 21-30 years probably because most people aged 21 to 30 years would still be in school and may not have the resources to invest in fish farming. This is in agreement with Bolorunduro [16] who reported that 41-50 years was the most active, productive years of fish farmers in Niger State. However, Usman [17] noted that 31-50 years was the economically active age group. The findings of this study further showed that most of the fish farmers in Enugu State are educated people who can easily adopt innovations and can take calculated risks in investments. Most of the fish farmers in Enugu State had at least a first school leaving certificate (FSLC). Fish farming in Enugu State is at its budding stage and an elitist enterprise as was also observed in Jos Plateau State by Wuyep *et al.* [18]. Consequently, most fish farmers in Enugu State had less than five years of experience in the fish farming business probably due to the fact that aquaculture practices are at its developmental stage in the State. This is in agreement with the reports of Akinrotimi [19] from a survey of brackish water aquaculture status in Rivers State.

Fish farming in Enugu State is a lucrative business although majority of the fish farmers sampled in the State indicated that they realized less than one hundred thousand naira (₦ 100,000) profit annually from sale of fish and fisheries products. They unanimously agreed that they make profit instead of losses in the enterprise and that the amount realized is a function of the amount invested. The profitability analysis of this study also agreed with that of Ashaolu *et al.* [20] who also noted that fish farming in Cross River State was profitable. *Clarias* species was the most prevalent fish species cultured in Enugu State during the study period probably due to the fact that the genus *Clarias* grows very fast, adapts to overcrowding and exhibit high tolerance to a wide range of environmental conditions [21]. These good qualities coupled with their high commercial demand and their ability to feed on a variety of food items makes the fish highly recommended for farming in Nigeria [22]. The results also showed that majority of the fish farmers in the State engaged in the production of table size fish than in either brood stock or fingerling production. This implies table size production has higher market acceptability in the study area since this stage is what is usually consumed. The type of product a farmer takes to the market is a function of the demand for that product. Although fingerling production is referred to as the “money spinner of fish culture enterprise” because of the high return on investment, it was not the dominant product of fish farmers in Enugu State because there is no ready market for the fingerlings due to few farmers available to buy them. That may

have been the reason most of the fish farmers in the State were into table fish production which had a ready market at that period.

Fish tends to grow better in earthen ponds since it is the closest to their natural habitat. However, because of scarcity of water and low water retention capacity of the soil in most parts of the study area, the fish farmers tend to engage fish farming in concrete and tarpaulin ponds because of their water conservation advantage and ease of maintenance. The implication of this is that farmers in the study area have to be relatively rich to be able to afford concrete fish ponds. This is in agreement with the report of Wuyep *et al* [18] who reported a similar trend in Plateau State, Nigeria. The fact that majority of the fish farmers have small ponds with low stocking capacity suggests that they are into small scale fish farming.

The study indicated that majority of the fish farmers sourced their fingerlings from private hatchery while few from the wild (natural water bodies in the study area). Majority of the respondent fish farmers sourced their brood stock from culture facilities while very few from rivers and streams. Majority of the farmers used extruded pelleted feed, some use animal wastes and local pelleted feed while very few use crop wastes like rice bran. This is in agreement with Izquierdo *et al.* [23] who reported that fish reared in intensive tank systems requires all nutrients in a completed pelleted diet since natural food is limited and fish cannot forage freely for natural foods. With regards to the feeding frequency, majority of the fish farmers feed their fish twice daily, few feed three times daily very few feed once daily. The implication is that the feeding regimen adopted by fish farmers in the State depended on the life stage of the fish being cultured. This is in agreement with Ozigbo *et al.* [24] who reported that the type of system depends on life stage of fish being cultured, size of operation, type of diet, available resources and personal preferences.

Form the results, most fish farmers carry out periodic water change as well as sort and stock their fish to different sizes, check water quality parameters like pH, water temperature and dissolved oxygen content of their culture water, give drugs for treatment, and cover their ponds with net. Some of them also weigh their fish periodically. This implies that fish farmers in the State adopt good management practices especially with regular assessment of water quality parameters. This is in agreement with Lebel *et al.* [25] who suggested that periodic taking of water quality parameters help the farmers to know the range of pH, dissolved oxygen, ammonia etc. and serve as a guide so that situations that can negatively affect fish growth can be prevented. More than half of the farmers always keep records of activities in their farms while a few did not keep any records at all. This implies that farmers in the State are well aware of the importance of record keeping in fish farms in order to ensure successful farm management.

Disease is one of the major factors militating against aquaculture development in Sub-Saharan Africa. From the result obtained in this study, bacterial and parasitic diseases such as hemorrhagic septicemias and Ich or white spot disease (Ichthyophthiriasis) as confirmed by consulted veterinary and laboratory services are the most prevalent diseases encountered by fish farmers in Enugu State. Similarly, Gonvid [26] reported that bacterial diseases are considered the major cause of mortality in aquaculture. Also, Henriksson *et al.* [27] reported that about one – third of economically important fish perish every year due to disease and about 60% of these lose were as a result of microbial pathogens such as bacteria, virus and fungi. The disease pathogens can affect a single fish and multiply rapidly to cause a substantial fish kill in a few days or weeks. Mortality of fish was recorded in the State during the last 6 months to the study. However, most of the farmers reported mortalities of less than 50 fish respectively among the fingerlings, table fish and brood stock. Among the three categories of fish produced by the farmers, mortality was generally higher among the fingerlings than the table fish and brood stock. This implies that mortality in fish occurs mainly during the fingerling stage of life and when all other management practices are adopted, the percentage mortality is usually low.

Majority of the fish farmers will usually self-medicate their animals during disease outbreaks while a few consulted animal health personnel and veterinary doctors. Although a few of the farmers did not give any

form of medication to their fish during disease outbreaks, some farmers who treated indicated that the outcome of the treatment instituted in their farm to combat disease outbreaks were usually very or moderately effective. The fact that less than fifty percent of the fish farmers agreed that the treatment instituted were effective was not surprising. This is because most of the fish farmers in the study area do not consult the veterinarians or other qualified professionals when there is outbreak of diseases in their farms but would rather recourse to self-medication. For proper health management of fish farms in the study area, there is the need to engage the services of Veterinary professionals that will carry out proper diagnosis and treatment when there is a disease outbreak. The implication of this self-medication is that by the time proper treatment can be organized, the disease may have become more serious and in some cases surviving fish are so weakened that effective treatment becomes difficult. Hence adequate measures to prevent the establishment of the disease are far better than cure. The possibility of these infections establishing in humans handling these fishes can also be of public health significance. The problems associated with indiscriminate use of medications have been reported in aquaculture [28]. The indiscriminate and frequent use of antibiotics in aquaculture as preventive and control measures have been questioned because of the development and spread of antibiotics resistance. The resistant bacteria transfer their resistant gene (R- plasmid) to other bacteria that have never been exposed to the antibiotics [29] ultimately leading to public health hazard.

The success of aquaculture enterprise, just like other economic activities, is a function of availability of information to fish farmers. This can be seen in the fact that most of the farmers either depended on their personal experience or fellow farmers for information regarding fish diseases and their treatment. It is worrisome that only a few of the fish farmers sourced such important information from qualified professionals such as veterinary officers despite the fact that most of them are educated up to the tertiary level. The fact that only few farmers sourced their information from the appropriate sources leaves much to be desired. The current practice where a fish farmer has little or no training, formal or otherwise, remains fraught with loss of vital technical advice and inadequate access to technical information [30], which ultimately leads to loss of financial resources.

CONCLUSION

Disease is one of the major factors militating against aquaculture development in Enugu State. Scarcity of funds for investment in fish farming has impacted negatively to fish farming as some farmers lack access to good quality water in the study area. However, the study provides enough evidence that fish farming in Enugu state is productive and lucrative.

ACKNOWLEDGEMENT

The authors express their appreciation to the Nigerian Tertiary Education Trust Fund (TETFUND) for providing the funding via Institution Based Research Intervention (TETFUND/DESS/UNI/NSUKKA/2018/RP/VOL.1) for this study.

REFERENCES

1. Amosu, A.O., Hammed A.M., Togunde K. A., Olabode, J.O. and Adeyemi, A. (2017). Possible Aquaculture Development in Nigeria: Evidence for Commercial Prospects. *Journal of Agricultural Science and Technology* 7 (B): 194-205.
2. Clavelle, T., Lester, S. E., Gentry, R. and Froehlich, H. E. (2019). Interactions and management for the future of marine aquaculture and capture fisheries. *Fish and Fisheries*, 20(2): 368-388
3. Emmanuel, O., Chinenye, A., Oluwatobi, A., and Peter, K. (2014). Review of Aquaculture Production and Management in Nigeria. *American Journal of Experimental Agriculture* 4 (10): 1137-51
4. Oladimeji, Y. U. (2018). Assessment of trend of artisanal fish production in Nigeria vis-a-vis implications on economic growth. *Nigerian Journal of Fisheries and Aquaculture*, 6(1): 37-46
5. FAOSTAT (2017) Food and Agriculture Organization of the United Nations Statistics Division. 2017. Country indicators: Nigeria, FAO Rome

6. Bradley, B. Byrd, K. Atkins, M., Isa, S. I., Akintola, S. L., Fakoya, K. A., Ene-Obong, H. and Thilsted, S. H. (2020). Fish in food systems in Nigeria: A review. Penang, Malaysia: WorldFish. Program Report: 2020-06
7. Amirzadeh Moradabadi, S., Ziaee, S., MehrabiBoshraadi, H. and Keikha, A. (2020). Effect of Agricultural Sustainability on Food Security of Rural Households in Iran. *Journal of Agricultural Science and Technology*, 22(2): 289-304
8. NBS (National Bureau of Statistics) (2017). Nigerian's fish production 2010–2015. National Bureau of Statistics (NBS), Nigeria. [https:// www.nigerianstat.gov.ng/elibrary](https://www.nigerianstat.gov.ng/elibrary).
9. Tripathi, A. D., Mishra, R., Maurya, K. K., Singh, R. B., & Wilson, D. W. (2019). Estimates for world population and global food availability for global health. In: *The role of functional food security in global health*. Academic Press, Pp. 3 - 24.
10. Anthony, O. and Richard, J. (2016). Contribution of aquaculture to poverty reduction & food security in Nigeria. *Journal of Applied Microbiology & Biotechnology Research*, 4, 26-31
11. Brummett, R. E., Lazard, J. and Moehl, J. (2008). African aquaculture: Realizing the potential. *Food Policy*, 33 (5): 371 – 385.
12. Gomma, A. and Rana, K. (2007). Inter-household and Intra-house hold Patterns of Fish and Meat Consumption in two states in Nigeria. *British Journal of Nutrition*, 145-152
13. Fapohunda, O.O., (2005): Analysis of bio-technical and socio-economic factors affecting agricultural production in Ondo State, Nigeria. Ph.D. Thesis, Federal University of Technology, Akure, Nigeria
14. Ali, M. H., Chowdhury, F. S., Ashrafuzzaman, M., Chowdhury, M. A. and UK-Hague, M. R. (2014): Identification, pathogenicity, antibiotic and herbal sensitivity of Edwardsiella ictaluri causing fish Diseases in Bangladesh. *Current research in Microbiology and Biotechnology* 21(1): 292 – 297
15. Emeasoba, U. R. B. (2012). Land ownership among the Igbos of South East Nigeria: A case for women land inheritance. *Journal of Environmental Management and Safety*, 3 (1): 97 – 117.
16. Bolorunduro, P. I. (2003). Improved fisheries technology and approaches for dissemination: A case study for Niger state. In: Proceedings 6th Fisheries Society of Nigeria (FISON) Annual National Conference, Maiduguri (November, 4th – 9th, 2003). Eyo, A. A. and Ajao, E. A. (eds.), Fisheries Society of Nigeria, Maiduguri. 74 – 79.
17. Usman, A. H. (2009). *Essential of Agricultural Economics*. 2ndEdn., Impact Publishers Nigeria.
18. Wuyep, S. Z., and Rampedi, I. T. (2018). Urban Fish Farming in Jos, Nigeria: Contributions towards Employment Opportunities, Income Generation, and Poverty Alleviation for Improved Livelihoods. *Agriculture*, 8(7): 110-126.
19. Akinrotimi, O. A. (2011). Issues limiting the expansion of brackish water aquaculture in the coastal areas of Niger Delta. In R. J. Kolo and A. M. Orire (Eds). Proceedings of the 26th Annual Conference of Fisheries Society of Nigeria, Minna, Niger state. 28th November – 2nd December, 2011. Pp 169 – 178.
20. Ashaolu, O. F., Akinyemi, A. A. and Nzekwe, K. (2005). Economic viability of homestead fish production in Abeokuta Metropolis of Ogun State, Nigeria. *Asset series A.*, 6 (2): 209 – 220.
21. Dogah, W. (2020). *Studies on aspects of the biology of Clarias gariepinus and heterobranchus longifilis from river Offin: Towards their culture development in Ghana* (Doctoral dissertation, University of Cape Coast)
22. Omeje, V. O. and Chukwu, C. C. (2014). Prevalence of *Aeromonas hydrophila* isolates in cultured and feral *Clarias gariepinus* of the Kainji Lake area, Nigeria. *Nigerian Veterinary Journal*, 35 (1): 948 – 955.
23. Izquierdo, M. S., Ferná'ndez-Palacios, H. and Tacon, A. G. (2001). Effect of broodstock nutrition on reproductive performance of fish. *Aquaculture*, 127: 25 – 42.
24. Ozigbo, E., Anyadike, C., Forolunsho, G., Okechukwu, R. and Kolawole P. (2013). Development of an Automatic fish feeder. International Institute of Tropical Agriculture, Postharvest Unit, Ibadan. *African Journal of Root and Tuber Crop*, 10 (1): 27 - 32.

25. Lebel, L., Lebel, P., and Chuah, C. J. (2019). Water use by inland aquaculture in Thailand: Stakeholder perceptions, scientific evidence, and public policy. *Environmental management*, 63(4): 554-563
26. Govind, P., Madhuri, S., Shrivastav, A. B. and Sahni, Y. P. (2012). Overview of the treatment and control of common fish diseases. *International Research Journal of Pharmacy*, 3 (7): 123 - 127.
27. Henriksson, P. J., Rico, A., Troell, M., Klinger, D. H., Buschmann, A. H., Saksida, S. *et al.* (2018). Unpacking factors influencing antimicrobial use in global aquaculture and their implication for management: a review from a systems perspective. *Sustainability science*, 13(4): 1105-1120
28. Reverter, M., Sarter, S., Caruso, D., Avarre, J. C., Combe, M., Pepey, E. *et al.* (2020). Aquaculture at the crossroads of global warming & antimicrobial resistance. *Nature Communications*, 11(1): 1-8
29. Bello-López, J. M., Cabrero-Martínez, O. A., Ibáñez-Cervantes, G., Hernández-Cortez, C., Pelcastre-Rodríguez, L. I., Gonzalez-Avila, L. U. and Castro-Escarpulli, G. (2019). Horizontal gene transfer and its association with antibiotic resistance in the genus aeromonas spp. *Microorganisms*, (9): 363 – 374
30. Igoche, L. E., Makwin, F., Akpenseun, T. T., Kaye, J. and Oyedapo, F. A. (2019). Assessment of fish farming in plateau state, north Central Nigeria. *Asian Journal of Fisheries and Aquatic Research*, 4 (1): 1-10.