STATUS OF FISH FARMING PRACTICES: A CASE STUDY OF SELECTED FISH FARMS IN LAGOS STATE, NIGERIA

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ABSTRACT

Fish is essential in human diet, providing the necessary protein components. In aquaculture, fish are produced under controlled environment to support food security. This study assessed the current status of fish farming practices and identified the available resources and culture management practices deployed for fish production in the aquaculture industry in Lagos State. One hundred fish farms were randomly selected from 3 agricultural zones in Lagos, Nigeria; East, West and Far-East. Structured questionnaires were used for data collection, which were analysed using MS Excel tool and descriptive statistics. Men below 50 years of age constitute 53.08% of overall respondents. Use of boreholes as water source was predominant in the East (92.59%) and West (76.67%), while stream/spring was more in the Far-East (75%). Majority of the fish farms operates small-scale; monoculture of clariid catfish is predominant. The stocking densities of ≤ 100/m^3 (fingerlings), ≤ 50/m^3 (juveniles and adults) and 2,000/m^3 (fry) were estimated in grow-out and hatcheries accordingly. Annual average production of fish seeds were ≤ 100,000 while table sized fish (500 – 999g) was prominent per cycle. Mortality was caused in order of importance: water pollution, infections and feed contamination. Therefore, good aquaculture management practices should be adopted to improve production.

Key Words: Fish culture, Clariid catfish, Current status, Challenges

INTRODUCTION

The inability of capture fisheries to meet global fish demands necessitated the development of aquaculture industry to support the protein needs of the growing population (Committee for Inland Fisheries and Aquaculture of Africa, CIFAA, 2017) which was buttressed by global population projection of about 8.6, 10.1 and 12.7billion by 2030, 2050 and 2100, respectively (UN, 2017). Therefore, fish food production is considered to contribute immensely to global food security (Onyekuru *et al.,* 2019). Fish is crucial for nutrition, food security, and livelihoods by providing the highest-quality protein source and a variety of other nutrients especially essential amino acids and fatty acids that our body needs, in addition to vitamins and other vital elements such as iodine and selenium which are not present in other plants and animal products (Kwasek *et al*., 2020). It accounts for about 17% of the global population's intake of animal protein (Shah and Mraz, 2020).

In Nigeria, the food production and population growth maintain a parallel trend leading to perpetual increase in food insecurity with 2.5% increase in food production while food demand increased above 3.5% as a result of 2.8% increase in population growth (FAO, 2014), leading to low animal protein intake of 6 – 8g per person per day (Iyagbe and Orewa, 2009) as against the minimum recommendation of 36g per person per day (FAO, 2018), culminating in endemic malnutrition (Semba, 2016). However, fish production has been a vital option among the solutions to alleviate the protein deficiency in Nigeria (Ubesie and Ibeziakor, 2012).

Aquaculture provides good protein source in human diet, employment, income generation and good return on investment to farmers (Shava and Gunhidzirai, 2017; Onoja, 2005). Nigeria is endowed with suitable environment to support culture of various fish species (Fact sheet, 2019), and the culturable fish species in Nigeria include Tilapia, *Clarias gariepinus*, *Heterobranchus* sp, Hybrid clariid, *Chrysichthys nigrodigitatus Megalops atlanticus* and *Heterotis* sp., among which the catfish is predominantly cultured followed by the tilapia *sp*. However, the abundant requisite resources for fish culture in Nigeria; natural water sources, extensive coastal area, culturable fish species, diverse feed ingredients and relatively cheaper labour must be adequately harnessed to improve fish production and minimise protein deficiency and malnutrition. A review of the current status of aquaculture practices could reveal areas requiring attention, and proffer solutions toward achieving sustainability in fish production by culture in the country.

MATERIAL AND METHODS

Description of the Study Area

The investigation was carried out in Lagos State, Nigeria (Figure 1). It is the largest coastal state in southwest Nigeria along the Bight of Benin and is 3,345 square kilometers in size. It is situated between longitude $2^0$41'20"E and $4^0$21'10"E and latitude 6°22′10″N and $6^0$42'15"N (Google Earth Satellite Imagery, 2018). The cardinal boundaries shared with Lagos are with Ogun State on the North and East, the Republic of Benin on the west and coast of the Atlantic Ocean on the south. Lagos State has a humid, dry, wet climate that borders on a tropical monsoon climate. There are two rainy season peaks: the first peak occurs between April and July, followed by a brief respite from precipitation in August and September, and the second peak in October and November. The dry season takes place from December to March, and harmattan is brought on by trade winds from the Sahara Desert in the northeast ("Weather BBC Weather Lagos Nigeria, 2011)

The temperature range in Lagos is between 23°C (74°F) and 34°C (93°F) while the average annual temperature is 27.8ºC (82ºF) with the hottest month being March with a mean temperature of 29.7°C (85.5°F) and the coldest month being August with a mean temperature of 26°C (78.8°F). The wettest month is June, with an average rainfall of 12.2 inches over a period of about 16 days. The driest month is January, with an average rainfall of 0.6 inches over a period of about 2 days (Climatestotravel.com, 2022). The common vocations of indigenous Lagosians include fishing, farming, and livestock rearing, while artisanal fishing is most common in the coastal locations (such as Epe, Badagary, Eleko, and Ikorodu) and inland waterways (Itowolo, Iyana – Oworo, Agboyi and Iwaya). Currently, the state operates three agricultural zones: Lagos East (LE), Lagos West (LW), and Lagos Far – East (LFE).

Data Size and Sampling Procedures

The list of functioning farms was obtained from the Lagos State Agricultural Development Authority (LSADA) and 3% of the fish farms were randomly selected from the list of operating farms to have 54 farms (LE), 30 farms (LW) and 16 farms (LFE) making the total of one hundred (100) fish farms sampled. Structured questionnaires and in-person conversations with farm owners and attendants were used to gather primary data. Each questionnaire's administration with the respondent took an average of 30 to 45 minutes. All of the distributed questionnaires were administered and used for analysis. Socioeconomic factors of the fish farmers, such as their sex, age, education level, marital status, and years of farming experience, are also recorded, along with management techniques like water source, fish species, culture periods, stocking density, biosecurity status, disease awareness, and record-keeping.

Data Analysis

The survey data were sorted and categorized according to the stratified agricultural zones and the corresponding fish farmers. The data were analysed using descriptive statistics (frequency count and percentages) with the MS Excel application.

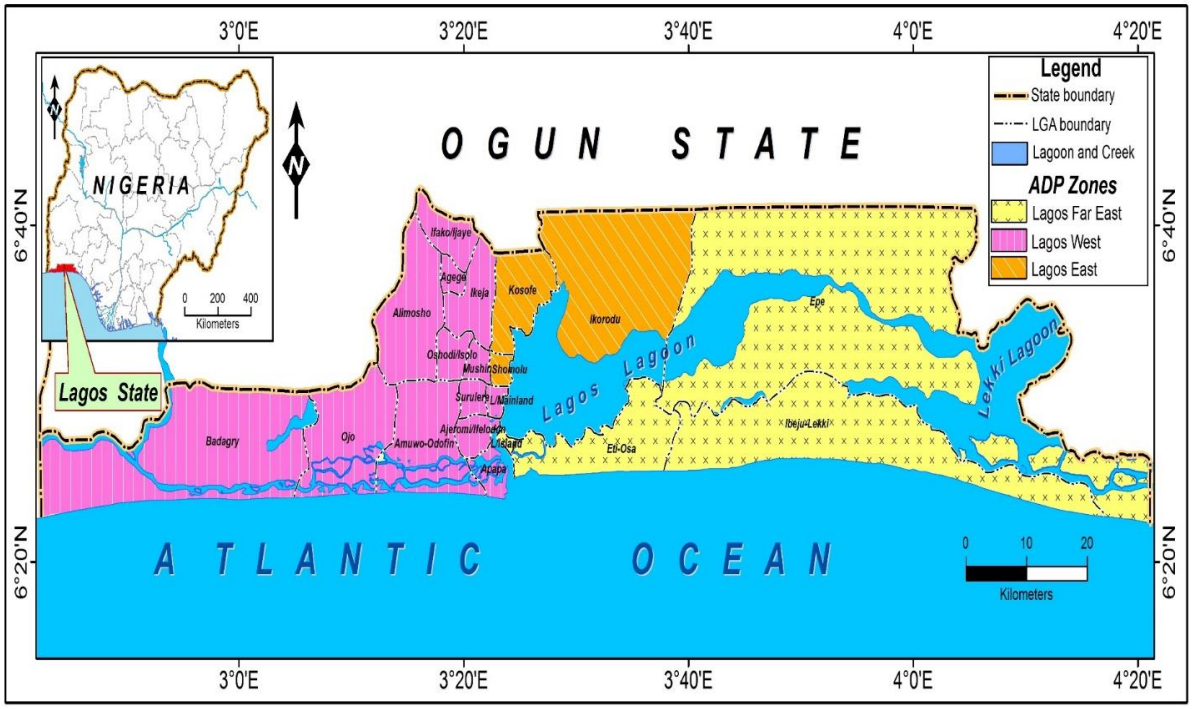

Figure 1: Map of Lagos State showing the three Agricultural Zones

RESULTS

Socio – economic characteristics of fish farmers

Men were more in fish farming compared to women with data in Table 1 showing LE had (85.19%), while LW recorded (86.67%), and LFE (100%). The majority of the respondents were above the age of 50 in LE (40.74%) and LFE (50%) while 50% of those in LW were between the ages of 31 and 40. The majority of farmers in LE (83.19%), LW (100%) and LFE (81.25%) were married. Additionally, the data revealed that 87.04% and 76.67% of respondents raising fish in LE and LW respectively, were graduates while 62.5% respondents in LFE were secondary school leavers. The majority of farmers in LE (70.37%), LW (56.67%), and LFE (56.25%), had 6 to 10 years of experience, whereas 31.25% farmers in LFE, 9.26% in LE and 13.33% in LW had more than 10 years of experience in fish farming.

The management practices in fish farms in Lagos state Management practice and cultured species

Monoculture of clariid catfish was more prevalent throughout all the zones, accounting for 83.33% (LE), 86.67% (LW), and 62.50% (LFE) respondent followed by polyculture of clariid catfish and Tilapia species which were 14.81%, 10%, and 12.50% in LE, LW, and LFE, respectively (Table 2). Along with *Clarias gariepinus*, *Heterobranchus* sp., *Gymnarchus niloticus* and *Heterotis niloticus* were other species raised on the farms. The types of culture facilities available on farms for fish culture varied from earthen ponds to concrete tanks to plastic tanks and tarpaulin vats, with concrete tanks being the most common in LE (50%) followed by tarpaulin vats in LW (30%) and earthen ponds in LFE (75%), a similar pattern was obtained in terms of usage of facilities for fish culture with LE (53.70%), LW (40%) and LFE (75%), respectively (Table 3).

The source of water and pattern of renewal

The sources of water used for fish production were boreholes, well, stagnant ponds and stream (Table 4). Borehole is the major source of water in LE (92.59%) and LW (76.67%), but stream/spring constitute the major source in LFE (75%), which made water readily available for renewal in all the culture facilities. In LE and LFE, 24.07% and 50% of the earthen ponds were renewed weekly respectively while 13.33% were renewed bi – weekly in LW. Farmers in LE (31.48%), LW (23.33%) and LFE (6.25%) renewed their water weekly in concrete tanks while 12.50% (LFE) and 33.33% (LW) farms renewed their water daily. The water parameters were poorly checked in LE (72.22%), LW (83.33%) and LFE (81.25%).

Feed and feeding in the hatchery and grow – out

Most of the farms used commercial feed; 2 different brands for the hatchery and 9 brands for grow – out. Floating feed was mostly used to feed juveniles in LE (33.33%), fry in LW (26.67%) and LFE (18.75%) whereas sinking feed was mostly used to feed juveniles in LFE (31.25%) as well as the combination of feeds in LFE (37.50%) (Table 5). In the hatchery, 50%, 71.43% and 75% of the farmers fed their fish seeds 3 – 4 times daily in LE, LW and LFE respectively, while only 28.57% of the respondents fed more than 4 times in LE. In grow – out, fish were mostly fed twice daily in LE (60%),

LW (56.25%) and LFE (83.33%) but only 25% of the farmers in LE fed fish once daily. In LW, 43.75% respondents fed their fish seeds more than 3 times per day.

The stocking density in hatchery and grow – out production Feed and

The stocking density for fish seeds and grow – out production was represented in Table 6. The culture facilities used in hatchery were concrete tanks, plastic tanks and tarpauling vats. The highest stocking density of > 5,000 fry/m^3 was estimated in concrete tanks in LE to be 3.70%, while density of 2001 – 3,500/m^3 in tarpaulin vats in LW was 10%, but in plastic tanks 6.25% of farms stocked their fry at > 5,000/m^3. In grow – out, 9.26% and 13.33% of farms sampled stocked fingerlings at < 100/m^3, 27.78% and 10% stocked juveniles at < 50/m^3, 22.22% and 6.67% stocked adults fish at < 50/m^3 in LE and LW respectively. Fingerlings were stocked at > 400/m^3 on 6.25% of the farms, while juveniles were stocked at < 50/m^3 on 31.25% of the farms, and 6.25% sampled farms stocked adults fish at < 50/m^3 in LFE.

Scale of operations and production capacity in hatchery and grow – out systems.

The culture periods engaged annually by farmers coupled with respective outputs in hatchery and grow – out systems were shown in Table 7. Most of the farmers producing fingerlings, practiced more than 4 breeding annually having LE = 64.29%. LW = 100% and LFE = 75% while 35.71% and 25% in LE and LFE had maximum of 4 breeding cycles each respectively per annum. The production of fingerlings was on a small scale operations with LE (71.43%), LW (66.67%) and LFE (25%) respondents producing ≤ 100,000 annually but vice versa with medium scale production (101,000 – 1,000,000) having highest respondent in LFE (75%) and least in LE (28.57%). No fish breeder was found in the threshold of large scale production of more than 1,000,000 fingerlings/annum.

In grow – out, most farmers practiced at least 3 cycles annually in LE (62.50%), LW (81.25%) and LFE (83.33%) while 37.50%, 18.75% an 16.67% were on 2 culture periods annually in LE, LW and LFE accordingly. The average weight of fish harvested were graded into 200 – 499g, 500 – 999g and ≥ 1000g with highest average weight at harvest found to be 500 – 999g in LE (70%), LW (81.25%) and LFE (58.33%) whereas fish ≥ 1000g were harvested in 12.50% farms each in LE and LW while 16.67% farms in LFE. Most of the respondents with small scale grow – out operations (0.1 – 6 tons/annum) were found in LFE (69.23%) followed by LE (48.94%). The majority of respondents in LW (61.11%) operated medium scale grow – out (6.1 – 32 tons/annum) followed by LE (40.43%). A similar trend was seen for large scale grow –out production (> 32 tons/annum) with 11.11% farms in LW and 10.64% farms in LE.

The status of biosecurity in fish farms by respondents in Lagos State

The current state of biosecurity measures in fish farms in Lagos State is highlighted in Table 8, where the majority of the measures were compromised by the farmers, such as restriction of visitors to the culture area [LE (9.26%], LW (20%), LFE (18.75%], demarcating the areas of the culture facilities [LE (22.22%), LW (33.33%), LFE (25%), separating the materials used in the culture units [LE (11.11%), LW (46.67%), LFE (18.75%], and providing foot disinfection dip at farm entrance [LE (5.56%), LW (10%), LFE(6.25%)] except the disinfection of culture facilities that were given priority before stocking in LE (87.04%), LW (100%) and LFE (93.75%).

During the cultured periods, the waste water was discharged into nearby canals, drainage channels, self-dug pits and irrigating the vegetable beds. Majority of the farmers in LE (64.81%) and LW (53.33%) discharged their waste water into drainage channels while 50% of farmers in LFE did the same. Different methods were used to dispose their dead fish, including burning, burying, processing to feed fish, throwing into surrounding bushes, processed to dog or cat food, leaving on water to serve as food for fish, and flushing into canals, pits, or adjoining ponds. The majority of farmers in LE (32.31%) and LFE (43.75%) buried their dead fish while 26.15% and 31.25%, respectively left it on water to be eaten by other fish but in LW, most of the farmers (32.26%) flushed their dead fish into nearby canals, pits, or adjacent pond whereas 25.81% respondents chose to bury their dead fish.

The status of disease awareness among fish farmers in Lagos State

The wellness of the fish starts from ability to study fish behavior under culture by noticing any abnormal signs that may need immediate and appropriate attention (Table 9). Most farmers in Lagos State reported daily routing checks for unusual behavior in their fish with LE (88.89%), LW (83.33%) and LFE (100). Although dead fish was occasionally experienced on farms as reported in LE (98.15%), LW (96.67%) and LFE (100%) but when occurred, grow – out were mostly vulnerable in LE (35%), LW (31.25%) and LFE (75%). The most attributable factor contributing to mortality was water pollution in LE (38.17%), LW (42.10%) and LFE (26.06%) followed by infections in LE (31.57%) and LW (23.70%) but feed contamination and other factors in LFE (21.75% each). In LE, LW and LFE, 90.74%, 96.67% and 100% farmers rarely noticed fish infections (Table 10). However, 40.74%, 56.67% and 62.50% farmers mentioned that they experienced fish diseases respectively

mostly 50% in dry season (LE), 33.33% and 43.75% in both seasons in LW and LFE accordingly especially on juveniles (43.06%) in LE, fingerlings and grow – out (27.10% each) in LW and grow – out (45.45%) in LFE. Moreover, some farmers in LE (66.67%), LW (43.33%) and LFE (43.75%) had knowledge about fish health and disease control management through vocational training. Inorganic substances (Salt, Oxytetracycline,Furaltadone,Enrofloxacin, Colistin , Aerosol, Phostoxin phosphate, Potassium perman ganate, Soda Ash, Ampicilin, Procaine penicillin, Aquaceryl Plus, Kenflox, Keproceryl, NCO (Neom ycin, Chloramphenicol and Oxytetracycline), Streptomycin, Flagyl, Fish biotics, Formalin, Lincomycin, Doxycycline, Huwa - san) and/or organic substance (Natural leaves - male pawpaw, bitter, scent, neem, plantain (dry/wet), moringa, garlic, ginger, charcoal, tangiri, smooty (fruit), Super Gro) were used as theurapeutic/prophylactic measure against fish infections. More farmers adopted the use of inorganic substances across the zone (LE – 74.07%, LW – 76.67%, LFE – 81.25%) whereas the use of organic substances is gaining attention in more than 6% farms across the zone.

The status of farm record keeping in hatchery and grow – out systems among fish farmers in Lagos State

Table 11 reported the status of record keeping in hatchery and grow-out farms. Regular farm records that were important to farmers in the hatchery included purchases of input materials (LE 42.86%, 50% each in LW and LFE); stocking rate (LE 57.14%, LW 50%); feeding rate (LE 64.29% and LW 42.86%); sorting (LE 64.29%, LW 100% and LFE 75%); and sales of fish seeds (LE 71.43%, LW 64.29%). However, large numbers of farms did not keep records of water parameters (LE 78.57%, LW 92.86% and LFE 100%); mortality (LE 71.43%, LW 92.85% and LFE 100%) and disease infection (LE 86.71%, LW 86.71% and LFE 100%).

In grow – out farms, water parameter records were rarely kept or ignored in LE by 87.50% farmers, 93.75% in LW and 75% in LFE likewise disease infection records by 85% farmers in LE, 93.75% in LW and 91.67% in LFE. However, most of the farmers kept records of items bought concerning the business as obtained from 90% farmers in LE, 81.25% in LW and 50% in LFE; stocking density kept by 87.50% farmers in LE, 75% in LW and 91.67% in LFE; feeding rate by 72.50% farmers in LE, 43.75% in LW and 41.67% in LFE; sorting records by 65% in LE, 62.50% in LW and 66.67% in LFE and records of sales of table sized fish kept by 95% farmers in LE, 68.75% in LW and 91.67% in LFE.

Table 1: Socio - economic characteristics of fish farmers (n = 100)

Background Characteristics	Lagos East (n = 54)		Lagos West (n = 30)		Lagos Far – East (n = 16)	
	Freq.	%	Freq.	%	Freq.	%
Gender of respondents						
Male	46	85.19	26	86.67	16	100
Female	8	14.81	4	13.33	0	0
Age distribution of respondents (yrs)						
< 21	1	1.85	0	0	0	0
21 – 30	3	5.56	0	0	0	0
31 – 40	9	16.67	15	50	6	37.50
41 – 50	19	35.19	9	30	2	12.50
> 50	22	40.74	6	20	8	50
Marital Status						
Single	7	12.96	0	0	3	18.75
Married	46	85.19	30	100	13	81.25
Widowed	1	1.85	0	0	0	0
Educational Status						
Primary	0	0	0	0	2	12.50
Secondary	7	12.96	7	23.33	10	62.50
Tertiary	47	87.04	23	76.67	4	25
Years of experience						
≤ 1	2	3.70	2	6.67	0	0
2 – 5	9	16.67	7	23.33	2	12.50
6 – 10	38	70.37	17	56.67	9	56.25
> 10	5	9.26	4	13.33	5	31.25

Freq. – Frequency; % - Percentages

Table 2: Mode of management practice and fish species cultured in different facilities

Culture fish and available facilities	Lagos East (n = 54)		Lagos West (n = 30)		Lagos Far – East (n = 16)	
	Freq.	%	Freq.	%	Freq.	%
Type of fish culture						
Monoculture	45	83.33	26	86.67	10	62.50
Polyculture	9	16.67	4	13.33	6	37.50
Culture species reared on farms						
Clariid Catfish (CC)	45	83.33	26	86.67	10	62.50
CC + Tilapia	8	14.81	3	10	2	12.50
CC + Heterobranchus	0	0	0	0	1	6.25
CC + Tilapia + Heterbranchus	1	1.85	0	0	1	6.25
CC + Tilapia + Gymnachus	0	0	0	0	1	6.25
CC + Heterobranchus + Gymnachus	0	0	0	0	1	6.25
CC + Tilapia + Heterotis (Arowana)	0	0	1	3.33	0	0

Table 3: Different culture facilities available in Lagos Agricultural Zones for fish culture

Culture fish and available facilities	Lagos East (n = 54)		Lagos West (n = 30)		Lagos Far – East (n = 16)	
	Freq.	%	Freq.	%	Freq.	%
Culture facilities available on farms						
Earthen ponds (Ep)	15	27.78	5	16.67	12	75
Concrete tanks (Ct)	27	50	4	13.33	1	6.25
Plastic tanks (Pt)	1	1.85	3	10	1	6.25
Tarpaulin vats (Tv)	1	1.85	9	30	0	0
Ep + Ct	0	0	1	3.33	0	0
Ep + Pt	1	1.85	1	3.33	0	0
Ep + Tv	0	0	1	3.33	0	0
Ct + Pt	2	3.70	3	10	2	12.50
Ct + Tv	4	7.41	1	3.33	0	0
Ep + Ct + Pt	1	1.85	0	0	0	0
Ep + Pt + Tv	0	0	1	3.33	0	0
Ep + Ct + Pt + Tv	2	3.70	1	3.33	0	0
Culture facilities with samples collection						
Earthen ponds	15	27.78	5	16.67	12	75
Concrete tanks	29	53.70	8	26.67	1	6.25
Plastic tanks	6	11.11	5	16.67	3	18.75
Tarpaulin Vats	4	7.41	12	40	0	0

Table 4: The source of water used for production of different developmental stages of fish

Source of water and frequency of exchange	Lagos East (n = 54)		Lagos West (n = 30)		Lagos Far - East (n = 16)	
	Freq.	%	Freq.	%	Freq.	%
Source of water						
Borehole	50	92.59	23	76.67	4	25
Well	2	3.70	3	10	0	0
Borehole + Well	0	0	3	10	0	0
Stagnant ponds	1	1.85	1	3.33	0	0
Stream/spring	1	1.85	0	0	12	75
Frequency of water renewal						
Earthen:						
Daily	1	1.85	0	0	0	0
Weekly	13	24.07	1	3.33	8	50
Bi - Weekly	1	1.85	4	13.33	4	25
Concrete tanks						
Daily	11	20.37	1	3.33	0	0
Weekly	17	31.48	7	23.33	1	6.25
Bi - Weekly	1	1.85	0	0	0	0
Plastic tanks						
Daily	3	5.56	2	6.67	2	12.50
Weekly	3	5.56	3	9.99	1	6.25
Bi - Weekly	0	0	0	0	0	0
Tarpaulin Vats						
Daily	2	3.70	10	33.33	0	0
Weekly	2	3.70	2	6.67	0	0
Bi - Weekly	0	0	0	0	0	0
Water Parameters checked:						
Yes	15	27.78	5	16.67	3	18.75
No	39	72.22	25	83.33	13	81.25

Table 5: The type of feeds and the frequency of feeding during culture periods

	Lagos East (n = 54)		Lagos West (n = 30)		Lagos Far - East (n = 16)	
Types of fish feeds used	Freq.	%	Freq.	%	Freq.	%
Floating Feeds						
Fry	8	14.81	8	26.67	3	18.75
Fingerlings	4	7.41	4	13.33	1	6.25
Juveniles	18	33.33	4	13.33	0	0
Adults	13	24.07	2	6.67	0	0
Sinking Feeds						
Fry	0	0	0	0	0	0
Fingerlings	0	0	2	6.67	0	0
Juveniles	0	0	2	6.67	5	31.25
Adults	1	1.85	1	3.33	0	0
Both						
Fry	0	0	0	0	0	0
Fingerlings	2	3.70	3	9.99	0	0
Juveniles	5	9.26	4	13.32	6	37.50
Adults	3	5.56	0	0	1	6.25
Feeding Frequency						
Hatchery						
1 - 2 Times	3	21.43	4	28.57	1	25
3 - 4 Times	7	50	10	71.43	3	75
> 4 Times	4	28.57	0	0	0	0
Grow - Out						
1	10	25	0	0	0	0
2	24	60	9	56.25	10	83.33
≥ 3	6	15	7	43.75	2	16.67

Table 6: The stocking density in hatchery and grow – out production systems in Lagos State

Stocking Density (m^3)		Lagos East (n = 54)		Lagos West (n = 30)		Lagos Far - East (n = 16)	
		Freq.	%	Freq.	%	Freq.	%
Hatchery (Estimation)							
Concrete tanks:	< 500	1	1.85	0	0	1	6.25
	501 - 2,000	0	0	0	0	0	0
	2001 - 3,500	0	0	0	0	0	0
	3,501 - 5,000	1	1.85	0	0	0	0
	> 5000	2	3.70	0	0	0	0
Plastic tanks:	< 500	1	1.85	1	3.33	0	0
	501 - 2,000	1	1.85	0	0	1	6.25
	2001 - 3,500	0	0	0	0	0	0
	3,501 - 5,000	1	1.85	0	0	0	0
	> 5000	0	0	1	3.33	1	6.25
Tarpaulin Vat:	< 500	0	0	0	0	0	0
	501 - 2,000	0	0	1	3.33	0	0
	2001 - 3,500	0	0	3	10	0	0
	3,501 - 5,000	0	0	1	3.33	0	0
	> 5000	1	1.85	1	3.33	0	0
Grow – out							
Fingerlings:	< 100	5	9.26	4	13.33	0	0
	100 - 200	0	0	0	0	0	0
	201 - 300	1	1.85	0	0	0	0
	301 - 400	0	0	0	0	0	0
	> 400	0	0	1	3.33	1	6.25
Juveniles:	< 50	15	27.78	3	10	5	31.25
	51 - 100	6	11.11	0	0	0	0
	101 - 150	0	0	0	0	0	0
	151 - 200	2	3.7	1	3.33	0	0
Adults:	< 50	12	22.22	2	6.67	1	6.25
	51 - 100	3	5.56	0	0	0	0
	101 - 150	1	1.85	0	0	0	0
	151 - 200	1	1.85	1	3.33	0	0

Table 7: Scale of operations and production capacity in hatchery and grow – out systems in Lagos State.

Culture period and production per annum	Lagos East (n = 54)		Lagos West (n = 30)		Lagos Far - East (n = 16)	
	Freq.	%	Freq.	%	Freq.	%
Culture periods per annum						
Hatchery						
1 to 4	5	35.71	0	0	1	25
≥ 4	9	64.29	14	100	3	75
Grow - Out						
1 to 2	15	37.50	3	18.75	2	16.67
≥ 3	25	62.50	13	81.25	10	83.33
Average numbers of fish seeds produced per annum (estimation)						
≤ 100,000	5	71.43	8	66.67	3	75
101,000 – 1,000,000	2	28.57	4	33.33	1	25
> 1,000,000	0	0	0	0	0	0
Average weight harvested (g)						
200 - 499	7	17.50	1	6.25	3	25
500 - 999	28	70	13	81.25	7	58.33
≥ 1000	5	12.50	2	12.50	2	16.67
Scale of Operations						
Hatchery						
Small	5	71.43	8	66.67	3	75
Medium	2	28.57	4	33.33	1	25
Large	0	0	0	0	0	0
Grow - Out						
Small	23	48.94	5	27.78	9	69.23
Medium	19	40.43	11	61.11	3	23.08
Large	5	10.64	2	11.11	1	7.69

Freq. – Frequency; % - Percentages

Table 8: The status of biosecurity in fish farms by respondents in Lagos State

Biosecurity Measure		Lagos East (n = 54)		Lagos West (n = 30)		Lagos Far – East (n = 16)	
		Freq.	%	Freq.	%	Freq.	%
Restriction to culture area	Yes	5	9.26	6	20	3	18.75
	No	49	90.74	24	80	13	81.25
Demarcation of culture facility areas	Yes	12	22.22	10	33.33	4	25
	No	42	77.78	20	66.67	12	75
Separation of culture unit materials	Yes	6	11.11	14	46.67	3	18.75
	No	48	88.88	16	53.33	13	81.25
Provision of foot disinfection dip at entrance	Yes	3	5.56	3	10	1	6.25
	No	51	94.44	27	90	15	93.75
Disinfection of culture facilities before stocking	Yes	47	87.04	30	100	15	93.75
	No	7	12.96	0	0	1	6.25
How do you discharge waste cultured water	Nearby Canal	15	27.78	10	33.33	8	50
	Drainage Channel	35	64.81	16	53.33	6	37.50
	Self dug pit	2	3.70	2	6.66	0	0
	Irrigation for vegetable	2	3.70	1	3.33	2	12.50
	Others	0	0	1	3.33	0	0
Disposal of dead fish	Burnt	1	1.54	1	3.23	0	0
	Buried	21	32.31	8	25.81	7	43.75
	Processed to feed fish	3	4.61	4	12.90	0	0
	Left to be fed by fish	17	26.15	3	9.68	5	31.25
	Processed for dog/cat	2	3.07	3	9.68	0	0
	Thrown to nearby bush	9	13.85	1	3.23	3	18.50
	Flushed to pond/canal/pit	11	16.93	10	32.26	0	0
	Others	1	1.54	1	3.23	1	6.50

Table 9: Routine observation of behavioural signs and possible factors to fish mortality in culture systems

	Lagos East (n = 54)		Lagos West (n = 30)		Lagos Far – East (n = 16)	
Factors of mortality	Freq.	%	Freq.	%	Freq.	%
Checking the unusual signs in fish behaviours						
Daily	48	88.89	25	83.33	16	100
Weekly	0	0	2	6.67	0	0
Fortnightly	1	1.85	0	0	0	0
Rarely	5	9.26	3	10	0	0
How often do you pick dead fish						
Regularly	0	0	1	3.33	0	0
Occasionally	53	98.15	29	96.67	16	100
Never	1	1.85	0	0	0	0
Suspected causes of mortality						
Infection	24	31.57	9	23.70	4	17.38
Water pollution	29	38.17	16	42.10	6	26.06
Feed Contamination	11	14.48	6	15.80	5	21.75
High Stocking Density	6	7.89	2	5.27	2	8.69
Electricity challenges	3	3.94	0	0	0	0
Sudden change in weather	0	0	1	2.63	0	0
Natural (Flood)	1	1.31	0	0	1	4.38
Others	2	2.63	4	10.53	5	21.75

Table 10: The status of disease awareness among fish farmers in Lagos State

Disease Awareness features	Lagos East (n = 54)		Lagos West (n = 30)		Lagos Far – East (n = 16)	
	Freq.	%	Freq.	%	Freq.	%
Disease Occurrence						
Yes	22	40.70	17	56.67	10	62.50
No	32	59.30	13	43.33	6	37.50
Rate of infection occurrences						
Always	1	1.85	0	0	0	0
Occasionally	49	90.74	29	96.67	16	100
Never	4	7.41	1	3.33	0	0
Season with infection						
Rainy	11	20.37	10	33.33	3	18.75
Dry	26	48.20	9	30	6	37.50
Both	14	24.07	10	33.33	7	43.75
None	3	5.56	1	3.33	0	0
Developmental Stages infection						
Fry	9	12.50	12	25	4	18.19
Fingerlings	10	13.89	13	27.10	2	9.09
Juveniles	31	43.06	9	18.77	6	27.28
Adults	19	26.39	13	27.10	10	45.45
None	3	4.17	1	2.10	0	0
Infected fish taken for laboratory diagnosis						
Hatchery	2	14.29	1	7.14	1	25
Grow - out	4	10	2	12.50	0	0
Knowledge about fish health and disease control management through vocational training						
Yes	36	66.67	13	43.33	7	43.75
No	18	33.33	17	56.67	9	56.25
Treatment/prevention of infection/clinical signs of fish						
Inorganic application	41	75.93	25	83.33	14	87.50
Organic applications	2	3.70	1	3.33	0	0
Both	3	5.56	4	13.33	1	6.25
None	4	7.41	0	0	1	6.25

Table 11: Record keeping in hatchery and grow – out farms

Farm Record Keeping	Hatchery						Grow – Out					
	LE(n = 14)		LW (n = 14)		LFE (n = 4)		LE (n = 40)		LW (n = 16)		LFE (n = 12)	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Procurement (inputs)												
Always	6	42.86	7	50	2	50	36	90	13	81.25	6	50
Occasionally	5	35.71	5	35.71	1	25	4	10	0	0	4	33.33
Never	3	21.43	2	14.29	1	25	0	0	3	18.75	2	16.67
Water Parameters:												
Always	3	21.43	1	7.14	0	0	5	12.50	1	6.25	3	25
Occasionally	7	50	6	42.86	2	50	25	62.50	8	50	2	16.67
Never	4	28.57	7	50	2	50	10	25	7	43.75	7	58.33
Stocking Rate												
Always	8	57.14	7	50	1	25	35	87.50	12	75	11	91.67
Occasionally	4	28.57	4	28.57	1	25	3	7.50	2	12.50	0	0
Never	2	14.29	3	21.43	2	50	2	5	2	12.50	1	8.33
Feeding Regime												
Always	9	64.29	6	42.86	0	0	29	72.50	7	43.75	5	41.67
Occasionally	4	28.57	6	42.86	2	50	7	17.50	7	43.75	6	50
Never	1	7.14	2	14.29	2	50	4	10	2	12.50	1	8.33
Sorting												
Always	9	64.29	14	100	3	75	26	65	10	62.50	8	66.67
Occasionally	3	21.43	0	0	0	0	6	15	6	37.50	4	33.33
Never	2	14.29	0	0	1	25	8	20	0	0	0	0
Mortality												
Always	4	28.57	1	7.14	0	0	14	35	5	31.25	9	75
Occasionally	6	42.86	8	57.14	1	25	14	35	9	56.25	1	8.33
Never	4	28.57	5	35.71	3	75	12	30	2	12.50	2	16.67
Disease infection												
Always	2	14.29	2	14.29	0	0	6	15	1	6.25	1	8.33
Occasionally	4	28.57	4	28.57	1	25	15	37.50	5	31.25	0	0
Never	8	57.14	8	57.14	3	75	19	47.50	10	62.50	11	91.67
Sale												
Always	10	71.43	9	64.29	1	25	38	95	11	68.75	11	91.67
Occasionally	3	21.43	3	21.43	2	50	2	5	3	18.75	0	0
Never	1	7.14	2	14.29	1	25	0	0	2	12.50	1	8.33

LE – Lagos East; LW – Lagos West; LFE - Lagos Far – East; Freq. – Frequency; % - Percentage

DISCUSSION

Socio – economics Characteristics of fish farmers

Majority of the farmers across the zone were males with few female (LE-14.81%, LW-13.33% and LFE-0%) indicating that fish farming demands masculine disposition due to labour intensive nature of the aquaculture industry, especially pond constructions, water discharge by water pumps, harvesting, sampling and so on which agreed with the findings of (Omitoyin and Osakuade, 2021; Omeje *et al.*, 2020; Ukpe *et al*., 2017). Involvement of different ages was observed among farmers in Lagos State indicating no age discrepancy in fish farming though the involvement of youth below 30 years were few only in LE signifying possible dwindling of young people from fish farming probably by diversifying from agriculture into other businesses or lack of starting funds. Overall, at least 50% of the respondents in each zone were between 31 – 50years representing the economically active age group similar to the report of (Akarue and Aregbor, 2015; Oluwasola and Ige, 2015). Above 80% of the respondents were married which may possibly ascertain the viability and sustainability of the business by striving to channel workable strategies towards productivity and profitability which agreed with the findings of Omitoyin and Osakuade (2021), Thompson and Mafimisebi (2014) and Omitoyin and Sanda (2013). Majority of the respondent had tertiary education which may contribute to ease of understanding and implementation of new innovations to increase technical efficiency of production, conforming to Igwe (2004) and Onyenweaku *et al*. (2005).

Assessment of production activities

Farming activities management

Borehole was the main source of water in LE and LW thereby making the farmers to adopt concrete tanks, plastic tanks, tarpaulin vats and combinations of two culture facilities which ascertained durability and afford them the opportunity of continuous production throughout the year. Also, these facilities could increase the expected technical efficiency of the farm (Igwe *et al*., 2011). The earthen ponds frequently used in LFE could be associated to the availability of stream and spring water for fish production which was considered cheaper than borehole. The findings in LE and LW were contrary to Shitote *et al*. (2013), with 82.80%, 16.70% and 0.50% farmers depending respectively on spring or stream as the water sources, indicating that the source of water depend on the geographical location of the farm site.

Clarias gariepinus was the main fish cultured across the zones which is in compliance with 90% fish farmers in Delta metropolis reported by Okpeke and Akarue (2015), 81% in Jos (Wuyep and Rampedi, 2018) and 61% in Calabar (Ele *et al.*, 2013). This may be due to attributable factors of the fish coupled with market value and consumers' acceptability. Earthen ponds were mostly used in LFE (Epe axis) probably because of high water table as a result of the surrounding waters while tarpaulin vats were frequently used in LW since it's a sandy environment and cost effective compared to construction and maintenance of concrete and plastic tanks. Many farmers invested in culture facilities but operated minimally by using few numbers because of insufficient fish seeds and increase in the cost of feeds.

The stocking densities of the fry were maintained at varying capacity based on the system adopted. The capacity of 2,000 fry per m^3 was reported in DWR partially agreed with the reports of Viveen *et al*. (1985) and Hecht *et al*. (1988). The common stocking density for juveniles was $\leq 50/m^3$ partially conformed to 7 – 100 catfish juveniles/m^3 (Ofor and Afia, 2015) and 4 – 12 catfish juveniles/m^3 (Abou – Zied, 2015). This indicates that farmer possibly stocked their facilities based on available resources and expected yield.

Most of the farmers in LE (79.63%) and LW (60%) predominantly used floating feeds probably because of the culture facilities (concrete tanks, plastic tanks and tarpaulin vats) commonly used while combination of both floating and sinking (43.80%) in LFE with most farms using earthen ponds unlike the varieties of feeds reportedly used with locally formulated feeds (48.80%) highly used (Adebo and Ayelari, 2011). In hatcheries, average of 65.50% breeders fed their fish three to four times per day while average of 66.40% grow out farmers fed their fish twice a day indicating the commitment of farmers in providing feeds despite the increase in cost of fish feeds contrary to 28.40% respondents that fed their grow out fish twice a day (Adeogun *et al.*, 2007).

However, the stocking density at juvenile and adult stages were similar which indicates that most of the final stocking density was done at juvenile stage and reared to the point of harvest (author per. comm.). The harvesting weight commonly sold among farmers across the zones ranged between 500 – 999g which was similar to the weight of fish (420 – 850g) sold at farm gate reported by Hecht, (2013). This may be due to the incessant increase in the price of fish feeds as well as the market demand. Nevertheless, lower stocking density was considered as a significant factor to growth performance and survival rate of *C. gariepinus* (Hecht *et al*., 1996) as well as high stocking densities possibly enhance the fish yield aggregate without much effect on mortality rate (Khatune-Jannat *et al.*, 2012; Pouey *et al*., 2011; Sorphea *et al*., 2010).

Small scale operation was predominant in hatcheries across the zones probably due to

insufficient quality broodstocks coupled with local demands of fish seeds from neighbouring farms and self-stocking of grow – out facilities. No farm engaged in large scale operation of fish seeds production possibly because of high technical – know – how required with assurance of regular availability of broodstocks. In grow – out production, LW recorded farms with highest medium and large scale productions which could be due to ability to harness all their culture facilities with quality seeds under intensive management practices.

Farming experience, biosecurity and diseases

More than 55% farmers in each zone had 6 – 10 years of fish farming experience with at least 9% farmers with more than 10 years, similar to the findings of Ifejika *et al*., (2007). Increase in the years of experience was expected to be an impetus to succeed in fish farming (Dey *et al*., 2002; Edward, 2000) and reduces management risk (Krause, 1995). However, the responses of most farmers to biosecurity were so poor thereby supporting the report of Faye *et al*. (2020) with 86.40% respondents showing less concern to biosecurity due to lack of knowledge and understanding of the importance of the measure on production. More so, the impressive educational status and years of experience of most farmers recorded were supposed to aid the understanding of aquaculture procedures for effective management of fish farms rather failed the compliance assessment with a very low rate, which may be as a result of negligence to farm hygiene and noncompliance to standard biosecurity rules and regulations (Ngueguim *et al*., 2020; Shitote *et al*., 2013).

Moreover, ability to observe fish behaviour in captivity and identify any unusual symptoms that may require attention is the first step in ensuring the wellbeing of fish. The importance of specialised training on fish health and disease control attended by most farmers in LE could be responsible for the least infections recorded while Lagos Far – East has the highest number of farmers without fish health training, indicating inability to respond effectively to fish disease challenges. However, awareness of fish diseases will help fish farmers identify signal of pathogenic risk and possible intervention to apply immediately. Juveniles were highly prone to infections as recorded in this study probably due to the stage being frequently stocked which means that they might be transferred with infection from the farms where procured (Okere and Adeyemo, 2014). Only few farmers across the zones took their infected fish for laboratory diagnosis despite claiming to have received vocational training on fish health and disease control probably because the existing laboratory is far from them or insufficient veterinarian or fish expert within the localities to attend to their immediate challenges.

CONCLUSION

Fish farmers in Lagos State were of different ages with men being prominent. The predominantly cultured fish species was *Clarias gariepinus*, reared in earthen ponds, concrete tanks, plastic tanks and tarpaulin vat using boreholes (or spring and stream in earthen ponds). Few farmers engaged in breeding of fish seeds while majority produced table sized fish of average weight of 750g in 3 – 4 times (or more) culture periods per annum. The stocking density for juveniles was < 50/m^3 and formulated feeds were commonly used in hatchery and grow – out farms with daily feeding of 3 – 4 times in hatchery and 2 time in grow – out. Most of the hatcheries and grow – out were operated on small scale except medium scale in LW grow – out. Farmers assumed that mortality was due to poor water conditions mostly, and infections rarely, since disease diagnosis were rarely carried out. Majority of the farmers showed negligence to biosecurity measures and record keeping of most farming activities. However, the varied practices among fish farmers showed that the systems (hatchery and grow –out) are not standardized which possibly resulted to different mode of operations during the cultured periods. Therefore, it would be of importance for policy makers and stakeholders to present and affirm the best management practices for fish farmers as operational guidelines with periodic fish farming trainings to assess compliance.

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