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Full Length Research

Assessment of Biosecurity Measures in Fish Farms of Udu Local Government Area, Delta State, Nigeria

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ABSTRACT: The study assessed biosecurity measures in fish farms in the Udu Local Government Area, Delta State, Nigeria. A purposive sampling technique was used to select four communities (Uwian, Orhuwhorun, Ugbisi and Kotokoto) in the study area, while cluster sampling was used to select one hundred and sixty-eight (168) fish farmers from Udu Local Government Area of Delta State, Nigeria. Data was collected using a structured questionnaire and interview. Descriptive and Chi-square statistic was used for data presentation and analysis. The study reveals that the majority of the fish farmers (67.9%) in the study area do not practice biosecurity measures and 58.9% have no understanding of biosecurity. From the study, fish farming is practised by youths between the age of 21 - 40 years (35.7%) and the majority of them have attained tertiary education (55.4%), yet have little experience in fish farming (2 - to 4 years) (31%). Hence, lack of fish farming experience, lack of awareness and understanding of biosecurity are major factors that influenced the non-compliance to biosecurity measures by fish farmers in the study area. This study created biosecurity awareness amongst the fish framers in the study area. The findings of this study will serve as a baseline source of information for further research. Fish farmers should adhere to strict biosecurity and biosafty measures in ponds and cages to avoid the spread of diseases in their fish population.

Keywords: Biosecurity, Delta State, fish farms, Nigeria.

INTRODUCTION

Biosecurity in aquaculture can be defined as a set of practices, procedures, policies, and regulations used to prevent the introduction and spread of pathogenic organisms (bacteria, viruses, fungi, parasites) and many aquatic invasive species (zebra mussels, rusty crayfish) (Dvorak, 2009). Undeniably, one of the most effective and affordable ways to minimize the introduction of pathogens or invasive species on a farm is to implement a biosecurity program (FIAC, 2010). Biosecurity in aquaculture is an important preventive measure to prevent the introduction of diseases to aquaculture facilities, and eventually in farmed species (Pruder, 2004). Outbreaks and spreading of diseases may happen as a repercussion of non-compliance in a bio-secured production system. Moreover, it may cause a significant decrease in the yield as a result of infected fish, and ultimately, loss of income to affected operators (Lightner, 2003). Biosecurity is a key requirement for the future development and expansion of aquaculture. With the decline of harvest fisheries, and the recognition that aquaculture is the fastest-growing major sector of animal agriculture, the concern for aquatic animal diseases is increasing.

Some of the general biosecurity components that could be followed in the production units include: regular fish health checks, quarantine of new stocks, disease surveillance, visitor restriction, fish vaccination, disinfection,

establishment of biosecurity work zones, biosecurity awareness among staff, restriction of wild animals and birds. Also, water quality monitoring, use of personal protection equipment (boots, waders etc.), good quality feed, proper storage of feed, use of foot dips/baths, and the cleaning of vehicles between visits to production facilities. In the hatchery and recirculating systems, the aspects to consider are disease-free groundwater supply, SPF eggs/fish, SPF feed, optimum nutrition, fish health monitoring, easy-to-clean units, features to remove dead fish, disinfection procedures and record keeping. Farm-specific and cost-effective vaccination strategies will provide resistance to several pathogens, good health and improved productivity (Lightner, 2003; FIAC, 2010).

Therefore, the general objective was to assess fish farmers' compliance with biosecurity measures on fish farms in the Udu Local Government Area of Delta State. And the specific objectives were to:

1. evaluate the socio-economic analysis of the respondents in the study area.
2. evaluate the biosecurity measures adopted by the farmers.
3. compare the level of compliance and non-compliance to biosecurity measures in the study area
4. identify the constraints affecting their level of compliance.

MATERIALS AND METHODS

Study area

This study was carried out in Ovwian, Orhuwhorun, Ugbisi and Ubogo community of Udu Local Government Area of Delta State. Delta State is Located in the South-South geopolitical zone of Nigeria with an estimated population of 5,663,400 (Dauda *et al*., 2015). It occupies a landmass of about 18,050 km² (6,970 sqm) of which more than 60% is land. The state lies approximately between 5°00’ and 6°45’E and 5°00’ and 6°30’N (Encyclopedia Britannica). It is bounded by Edo State in the north and west, on the east by Anambra, Imo and Rivers States. Southeast by Bayelsa State and on the southern extreme is the Night of Benin which covers about 160 kilometers of the states coastline. Delta State is predominantly inhabited by the Urhobo, Delta Igbo, Isoko, Ijaw, Itsekiri and the Olukumi people (Fathi *et al*., 2017). Udu is a Local Government Area in Delta State. Udu is one of the Urhobo kingdoms in Delta State. It is a boundary city/Local Government and a suburb of Warri metropolis and is connected from Enerhen by the Udu Bridge over Warri River (Figure 1).

Research design and type

Quantitative and qualitative research design was adopted with the use of well-structured questionnaire to survey the population using random sampling methods. Descriptive statistics was used to analyze the data collected from individual farmers examining the profile of the fish farm, the location, how the fish farmers apply biosecurity measures and the measures that are being applied in the study area. This research was investigative in nature, where the survey strategy involved observations, capturing of experiences and recording of perceptions of the participants in their natural farm environment. This technique summarized the data in an understandable way using frequencies and percentages (numerical) to reduce the number of responses to a mean score. From numerical data (mean score), the variables measured demography of the respondents, fish farm history and biosecurity measures applied in the fish farm.

Sample size and sampling procedure

Purposive and cluster sampling technique was used to find solutions to the research questions. A purposive sampling technique was used to select four communities (Uvwian, Orhuwhorun, Ugbisi and Kotokoto) in the study area while cluster sampling was used in selecting the farmers in the study area. Twenty-five (25), Fifty-one (51), Thirty-nine (39) and Fifty-two (52) questionnaire were administered to farmers in the selected communities (Ugbisi, Uvwian, Kotokoto and Orhuwhorun, respectively) to make a total of one hundred and sixty-eight (168) respondents.

Data collection

The method adopted in this study involved gathering information and data through primary and secondary data. The primary data was sourced from the respondents through the administration of a well-structured questionnaire and interviews with the fish farmers, veterinarians, etc, in the study area. While the secondary data includes literature and past studies on the topics under investigation; Journals, textbooks, and online magazines of other researchers.

Data analysis

The data collected from the study area was analyzed using descriptive statistics and chi-square analysis. Objectives 1, 2 and 4 were analyzed using descriptive statistics while objective 3 was analyzed using the chi-square analysis. The computation of chi-square statistics is given by:

$$X^2 = \sum \frac{Ei(Oi-Ei)^2}{Ei}$$

Where: X^2 = chi-square test statistic; O = Observed frequency; E = Expected or theoretical frequency; $\sum$= Sum of the calculated.

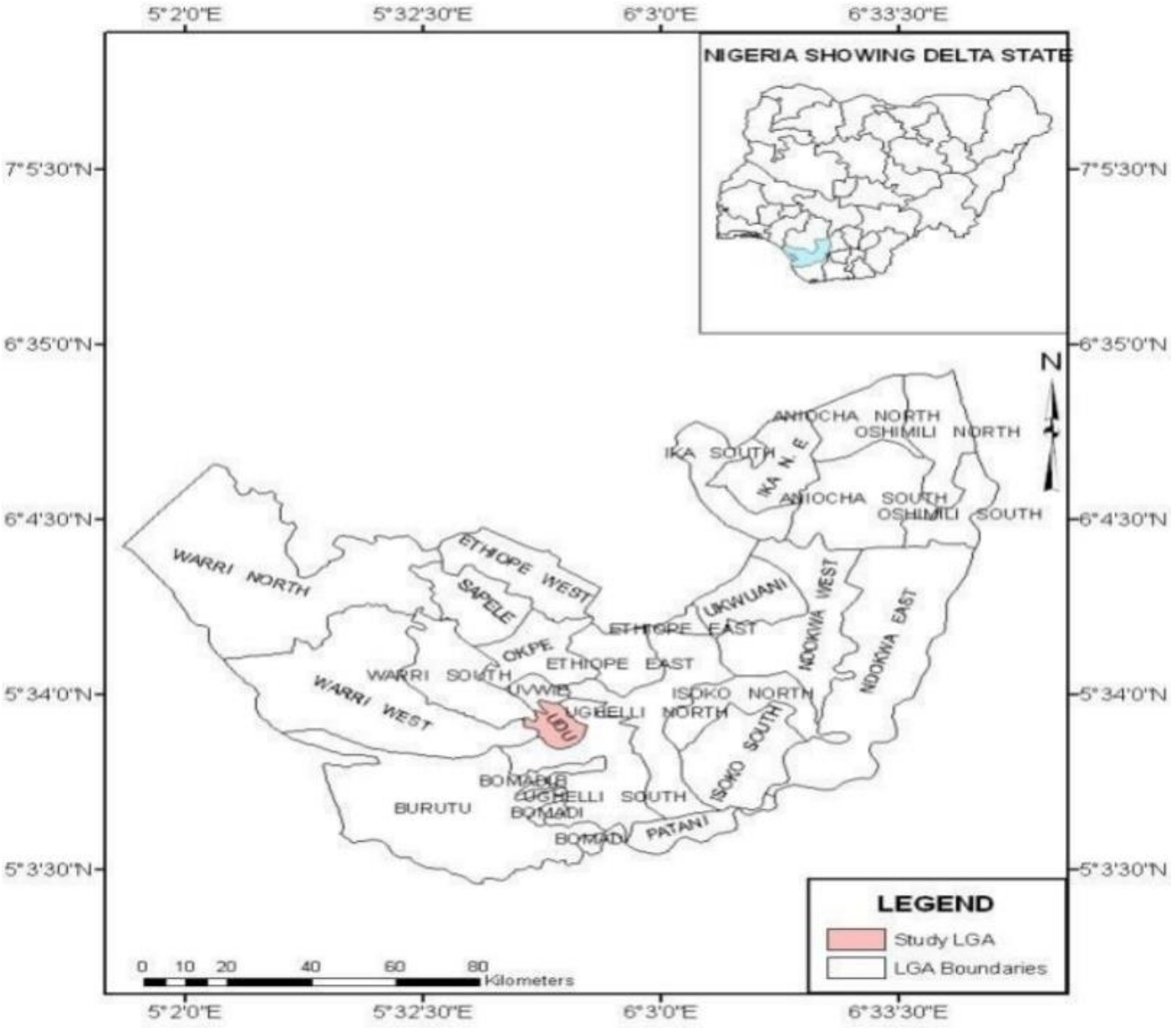

Figure 1. Map of Delta State showing Udu Local Government Area.

RESULTS

The results obtained from the analysis of the data were presented and distributed in line with the study's objectives.

Information on the socio-economic characteristics of the respondent

The result presented on Table 1 showed the age distribution of fish farmers in the Study area. The result showed that people involved in fish farming in the Udu Local Government Area of Delta State were mostly youth between the ages of 21 and 40 (35.7%). It showed that the youth are now participating in aquaculture, which is an encouragement because they were strong and open to the adoption of new technology, which will affect the needed growth in the industry. Their involvement in the aquaculture industry will also ensure food security in the region and the nation as a whole. Followed closely are young adults and mature adults aged 41 - 60 years (33.9%). 27.4% of fish farmers in the study area were mature people age 61 years above. It was also noted among the fish farmers in the study area younger youths and teenagers, and ordinary school boys that help their

Table 1. Distributions of the respondents according to age.

Age	Frequency	Percentage (%)
< 20years	6	3.6
21years - 40years	60	35.7
41years - 60years	57	33.9
61years and above	46	27.4
Total	168	100

Table 2. Distributions of the respondents according to marital status.

Marital status	Frequency	Percentage (%)
Single	66	39.4
Married	85	50.6
Widow	17	10.1
Divorced	0	0
Total	168	100

Table 3. Distributions of the respondents according to gender.

Gender	Frequency	Percentage (%)
Male	98	58.3
Female	70	41.7
Total	168	100

Table 4. Distributions of the respondents according to educational status.

Educational status	Frequency	Percentage (%)
No formal education	10	6.0
Primary education	12	7.1
Secondary education	53	31.5
Tertiary education	93	55.4
Total	168	100

parents < 20 years of age (3.6%).

The data collected showed that most of the fish farmers are married people with 50.6% of the respondents married, 39.4% of the fish farmers were single. While 10.1% of fish farmers in the study area widowed (Table 2).

The data collected showed that the fish farming business is dominated by the male gender where 58.3% of the 168 respondents used for the research were male, while 41.7% were female (Table 3). The implication is that fish farming activity seems to be more attractive to men than women in the Udu Local Government Area of Delta State.

The data collected showed that the greater number of people involved in fish farming in the study area are people who have obtained tertiary education (55.4%). 31.5% of the people involved in fish farming in the study area have obtained secondary education. 7.1% of fish farmers have obtained primary education. While 6% of fish farmers in the study area have no formal education (Table 4).

The data collected showed that 41.7% of the respondents are civil servants as well as engaging in fish farming as another source of income. 41.1% of the respondents are fish farmers, 16.7% of the respondents were fish marketers who also engaged in fish farming as another source of income. While 0.6% of fish farmers in the study area were private veterinarians and engaged in fish farming as well (Table 5).

Information on aquaculture practicing

The data collected showed that 31.5% of the respondents have fish farming experience of 2 - 4 years, and 20.2% of

Table 5. Distributions of the respondents according to occupation.

Occupation	Frequency	Percentage (%)
Fish farmer	69	41.1
Marketer	28	16.7
Civil servant	70	41.7
Public veterinarian	0	0
Private veterinarian	1	0.6
Total	168	100

Table 6. Distributions of the respondents according to fish farm experience.

Fish farm experience	Frequency	Percentage (%)
> 1 year	34	20.2
2years - 4years	52	31.0
5years - 7years	24	14.3
8years - 10years	34	20.2
11years and above	24	14.3
Total	168	100

Table 7. Distributions of the respondents according to species of fish cultured.

Species of fish cultured	Frequency	Percentage (%)
Catfish	168	100
Tilapia	0	0
Common Carp	0	0
Others	0	0
Total	168	100

Table 8. Distributions of the respondents according to type of pond system.

Type of pond system	Frequency	Percentage (%)
Concrete pond	18	10.7
Earthen pond	148	88.1
Plastic pond	1	0.6
Tarpaulin pond	1	0.6
Cage culture	0	0
Re-circulatory System	0	0
Others	0	0
Total	168	100

fish farmers in the study area have > 1 year and 8 – 10 years of fish farming experience, respectively. While 14.3% of fish farmers in the study area have 5 - 7 years and 11 years above of fish farming experience, respectively (Table 6).

The result presented in Table 7 shows the species of fish cultured in the study area. The result shows that fish farmers in Udu Local Government Area of Delta State were predominantly involved in catfish (*Clarias gariepinus* and *Heteroclarias*) farming (168%) and do not culture other species of fish. This is a result of inadequate knowledge of the culture of other species of fish.

The data in Table 8 shows that 88.1% of fish farmers in the study area are engaged in earthen ponds. 10.7% of the fish farmers in the study area have concrete ponds. 0.6% of the respondents in the study area have tarpaulin and plastic ponds, respectively. While 0% of the respondents in the study area have neither cage culture nor

Table 9. Distributions of the respondents according to culture system.

Culture system	Frequency	Percentage (%)
Intensive	38	22.6
Semi-intensive	128	76.2
Extensive	2	1.2
Total	168	100

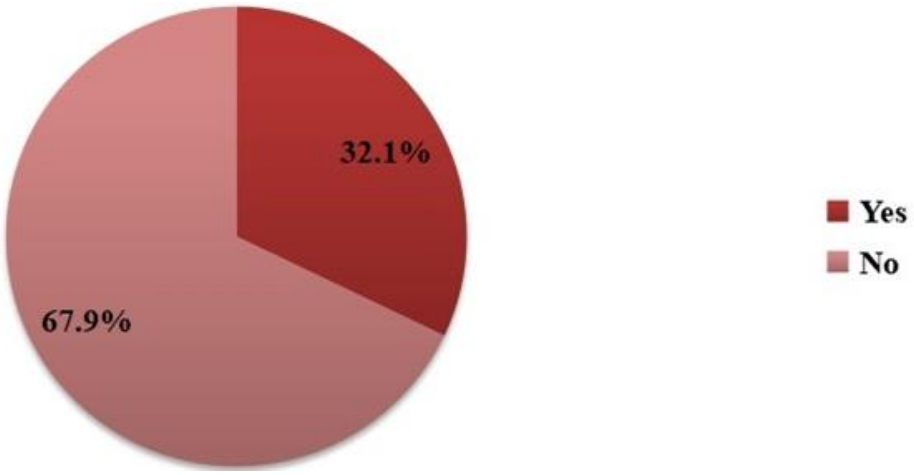

Figure 2. Showing bio-security awareness among fish farmers in the study area.

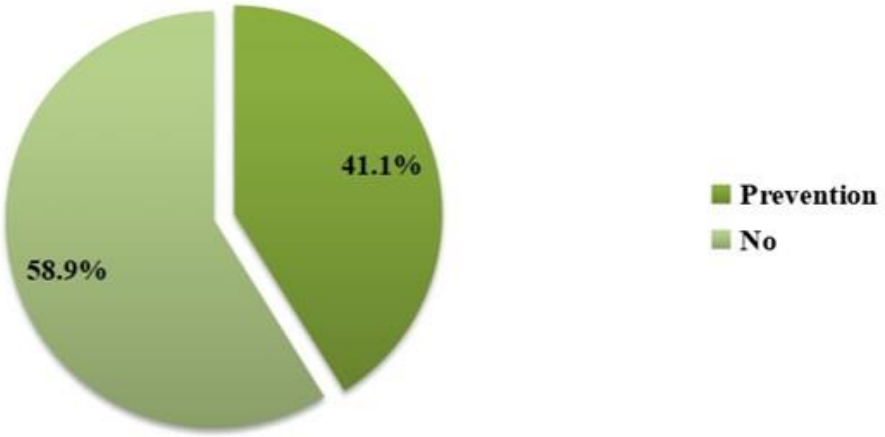

Figure 3. Showing understanding of bio-security among fish farmers in the study area.

re-circulatory system or other facility for the culture of fish.

The result presented in Table 9 showed the culture system practised by the respondents in the study area. The result showed that fish farmers in the Udu Local Government Area of Delta State majored in the semi-intensive culture system (76.2%). 22.6% of fish farmers in the study area practice intensive culture systems. While 1.2% of the respondents in the study area practice an extensive culture system.

Bio-security complaints

The data collected showed that 67.9% of fish farmers in the study area have no awareness of bio-security (Figure 2). While 32.1% of fish farmers in the study area have an awareness of bio-security.

The data collected showed that 58.9% of fish farmers in the study area have no understanding of bio-security (Figure 3). While 41.1% of fish farmers in the study area

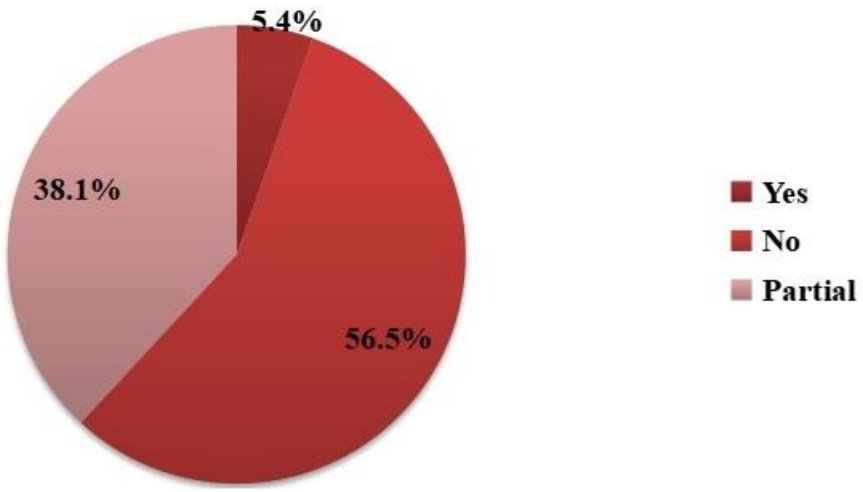

Figure 4. Showing practicing isolation by fish farmers in the study area.

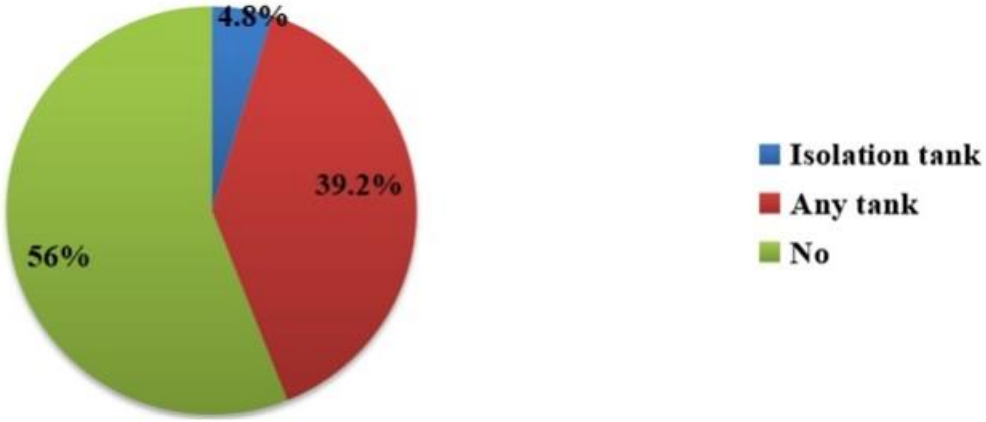

Figure 5. Showing where isolation is practiced among fish farmers in the study area.

have an understanding that bio-security is all about the prevention of pathogens from attacking the farm.

The data collected showed that 56.5% of fish farmers in the study area do not practice isolation of diseased fish, and 38.1% of the respondents in the study area practised isolation of diseased fish partially (Figure 4). While 5.4% of fish farmers in the study area practice isolation of diseased fish in their farms.

Information collected from the survey revealed that 56% of the respondents in the study area have no isolation tank hence do not isolate diseased fish (Figure 5). 39.2% isolate sick fish in any available tank because they do not have a special tank for this purpose. While 4.8% of the respondents in the study area have isolated tanks where fish infected by pathogens are quarantined and then nursed to perfect health.

The biosecurity measures applied as regards duration of isolation (how long?) practised by fish farmers in the study area are illustrated in Figure 6. It is noted that 41.1% of fish farmers in the study area observe isolation of infected fish for one (1) week. 39.3% of fish farmers in the study area did not observe the isolation of infected fish. 11.3% of the respondents in the study area observe isolation of infected fish for two (2) weeks. 8.3% of the respondents in the study area observe isolation of infected fish for two (2) days. None of the fish farmers in the study area observe isolation of infected fish for three (3) weeks (0%), four (4) weeks (0%), five (5) weeks (0%) and others (0%).

The data collected showed that 64.9% of the respondents in the study area do not practice the acclimatization of new stock (Figure 7), which is an important biosecurity measure that enables fish to adapt to a new environment without any health challenges. 23.8% of fish farmers in the study area partially practice acclimatization of new stock. While 11.3% of the respondents in the study area practice acclimatization of new stock.

The biosecurity measures applied to fish feed are

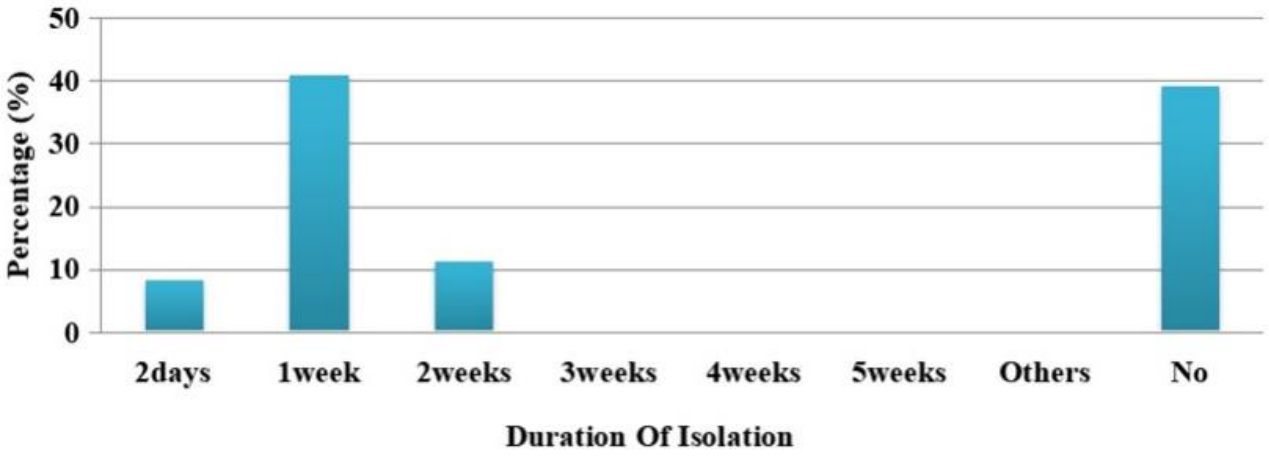

Figure 6. Showing the duration of isolation by fish farmers in the study area.

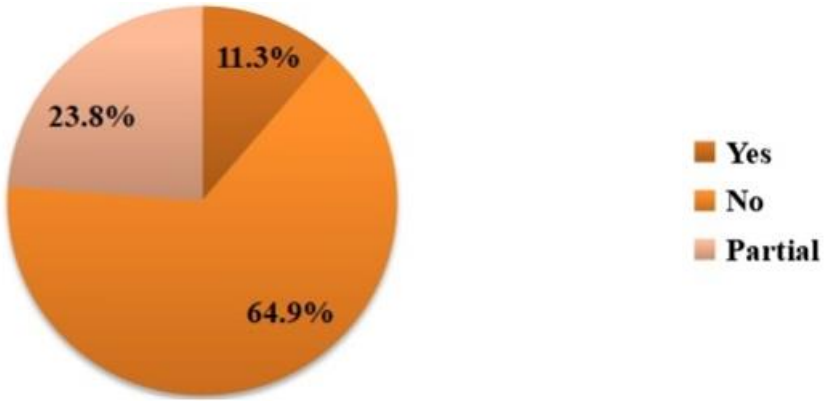

Figure 7. Showing practice of acclimatization by fish farmers in the study area.

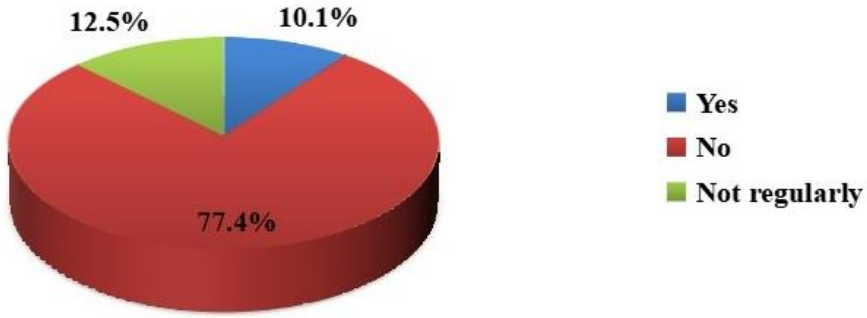

Figure 8. Showing practice of qualitative assessment of fish feed by fish farmers in the study area.

illustrated in Figure 8. The result showed that 77.4% of the respondents in the study area do not carry out qualitative assessment either on the fish feed or the local ingredients used for its preparation.12.5% of fish farms use fish feed without regular qualitative assessment either on the fish feed or on the local ingredients used for its preparation. 10.1% of the respondents carry out qualitative assessment either on the fish feed or on the local ingredients used for its preparation.

Information gathered on biosecurity measures applied to fish feed as regards proximate analysis are illustrated in Figure 9. The result showed that 73.8% of farmers use fish

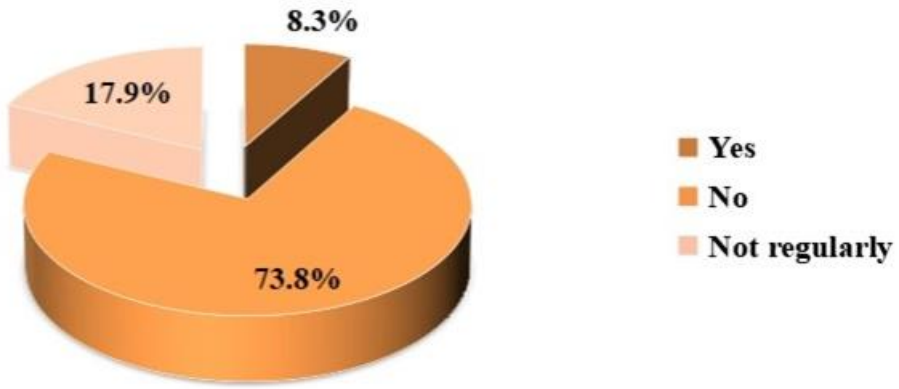

Figure 9. Showing practice of proximate analysis of fish feed by fish farmers in the study area.

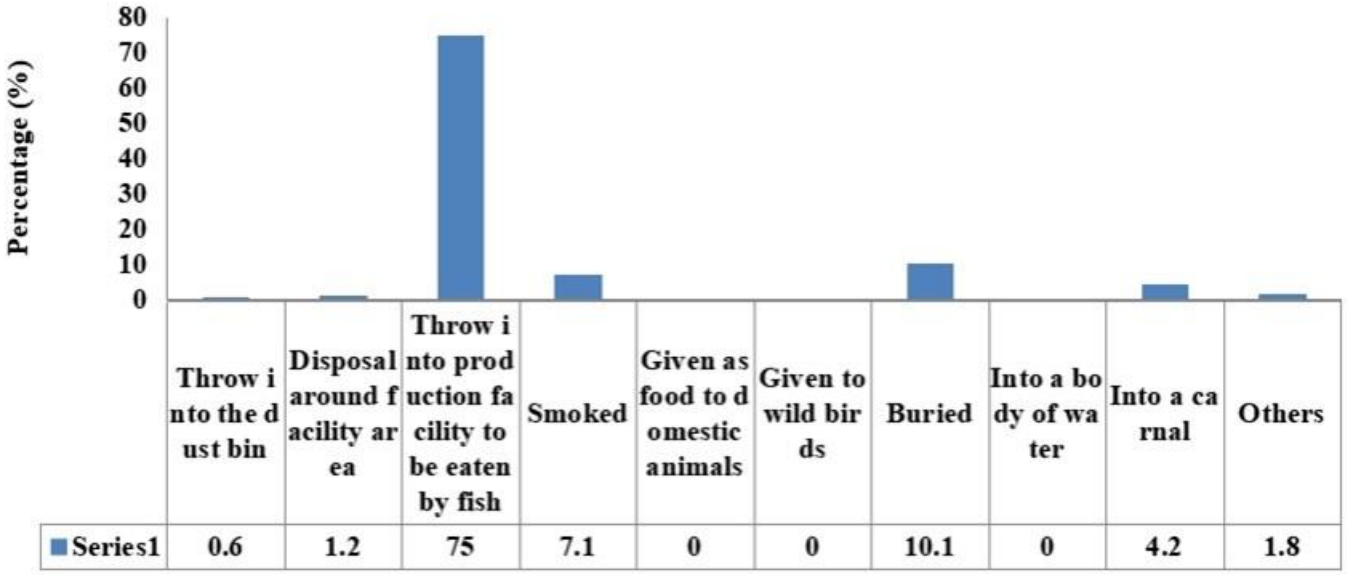

Figure 10. Showing disposal of dead Fish by fish farmers in the study area.

feed without any analysis of either on the food or the local ingredients used for its preparation. 17.9% of fish farmers use fish feed without regular analysis either on the fish feed or on the local ingredients used for its preparation. 8.3% of the respondents carry out qualitative assessment either on the fish feed or on the local ingredients used for its preparation.

The biosecurity measures applied as regards the disposal of dead fish by the fish farmers in the study area are illustrated in Figure 10. It was revealed from the research conducted that 75.0% of fish farmers in the study area dispose of their dead fish (es) in production facility to be eaten by fish. 10.1% of fish farmers in the study area buried their dead fish (es). 7.1% of the respondents in the study area smoked their dead fish (es). That is if they are old enough to be eaten. 4.2% of the respondents in the study area dispose of their dead fish (es) into carnal. 1.8% of fish farmers in the study area dispose of their dead fish (es) through other means. Some of the fish farmers dispose of their dead fish (es) around the facility area (1.2%). While 0.6% of the respondents dispose of their dead fish (es) in the waste bin. None of the fish farmers in the study area disposed of their dead fish (es) by either giving them as food to domestic animals or to wild birds (0%) respectively.

The biosecurity measures applied as regards control of wild fish/vectors/pests by the fish farmers in the study area are illustrated in Figure 11. It is revealed from the research conducted that 90.5% of the respondents in the study area have measures in place for the control of wild fish/vectors/pests. While 9.5% of fish farmers in the study area do not have measures in place for the control of wild

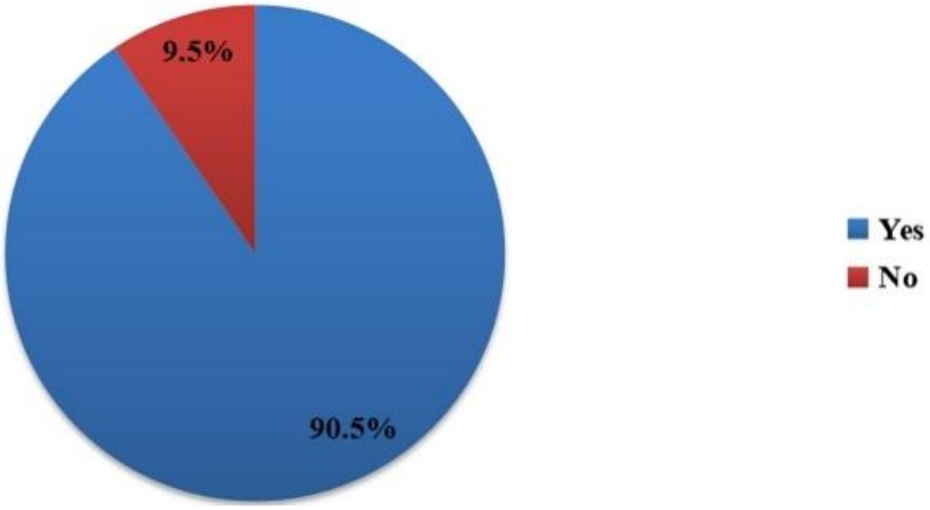

Figure 11. Showing control of wild fish/vector/pest by fish farmers in the study area.

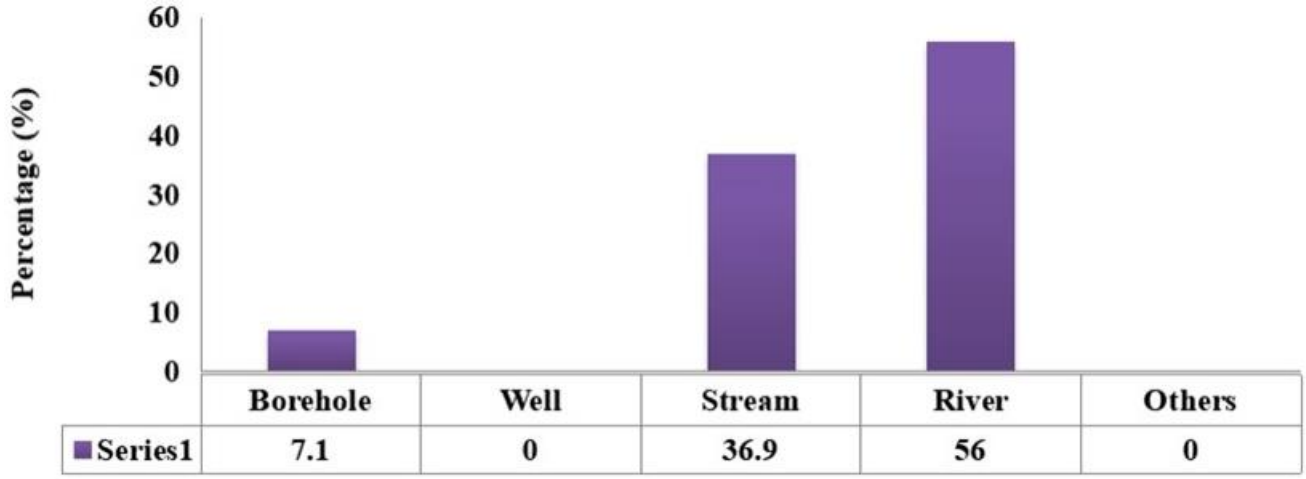

Figure 12. Showing water source by fish farmers in the study area.

fish/vector/pest. This is because most of the farms have earthen ponds thus fishes are exposed to predatory attacks from birds, reptiles, etc.

The data collected on water sources from respondents in the study area reveals that 56% of the respondents get their water from rivers (Figure 12). 36.9% of fish farmers in the study area get their water from stream. 7.1% of the respondents in the study area get their water from borehole. It was also noted that none of the respondents in the study area get their water from a well or other source.

The biosecurity measures applied as regards water quality monitoring by the fish farmers in the study area are illustrated in Figure 13. It is revealed from the research conducted that 66.7% of the respondents in the study area do not check water parameters. While 33.3% of fish farmers in the study area check water parameters.

The result presented in Figure 14 shows the response of the respondents in the study area on possession of functional foot dip. The result shows that fish farmers in Udu Local Government Area of Delta State do not have functional foot dip in their farms (94%). While 6% of the respondents in the study area have functional foot dip in their farms.

Information collected from the survey shows the response of the respondents in the study area on signs of fish diseases affecting fish. The result shows that 31% of fish farmers reported poor eating as a sign of fish disease affecting the fishes (Figure 15). 22.6% of fish farmers reported hanging on water surface/gasping for air, 14.3% of fish farmers reported swollen belly as a sign of fish disease affecting the fishes. Some fish farmers reported white spots on fish and pealing of mouth and tail (10%) respectively as a sign of fish disease affecting their fishes.

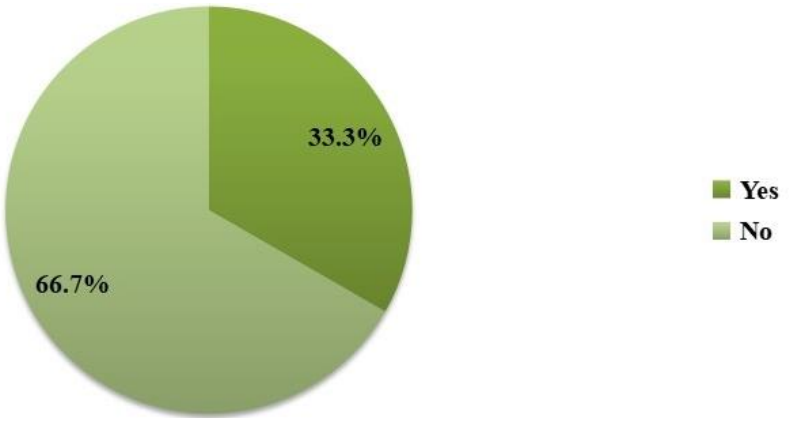

Figure 13. Showing Water Quality monitoring by the fish farmers in the study area.

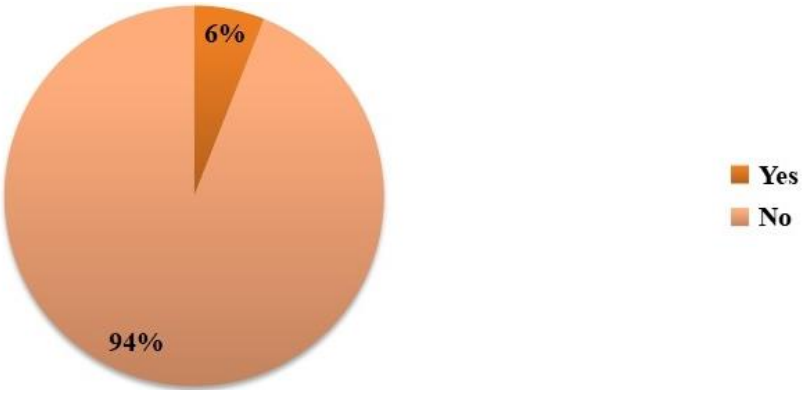

Figure 14. Showing practice of functional foot dip by the fish farmers in the study area.

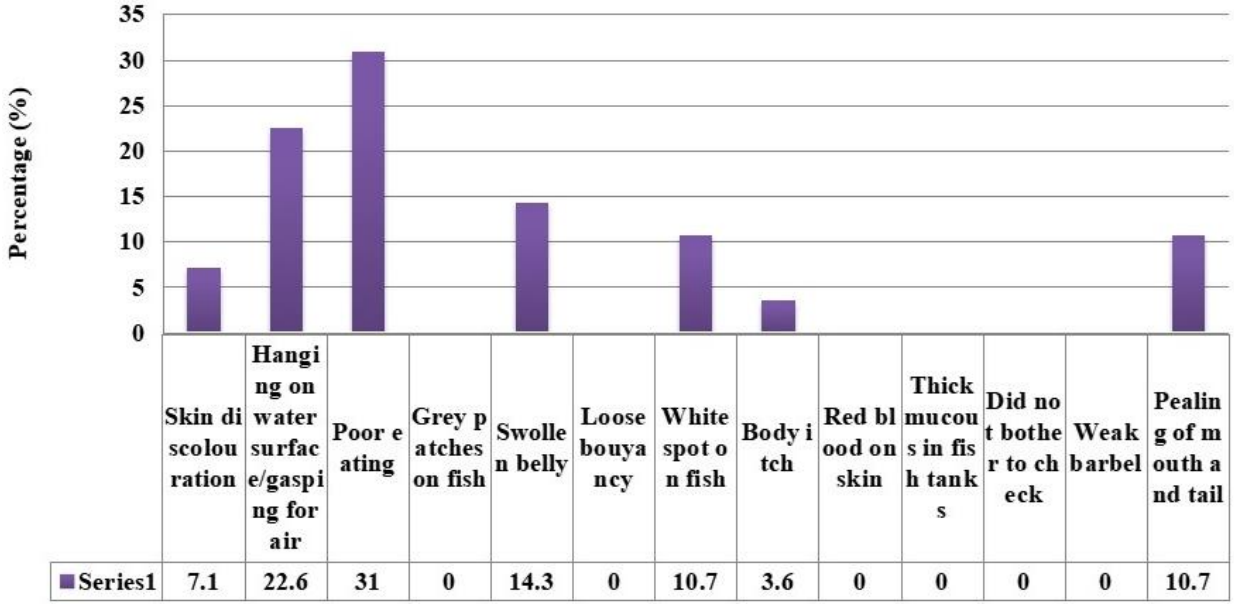

Figure 15. Showing Signs of Fish Diseases Affecting Fishes of the respondents in the study area.

Table 10. Distributions of the respondents according to numbers affected by fish diseases.

Numbers affected by fish diseases affecting	Frequency	Percentage (%)
1 - 10	10	6.0
11- 21	28	16.7
22 - 32	12	7.1
33 - 43	20	11.9
44 above	98	53.8
None	0	0
Total	168	100

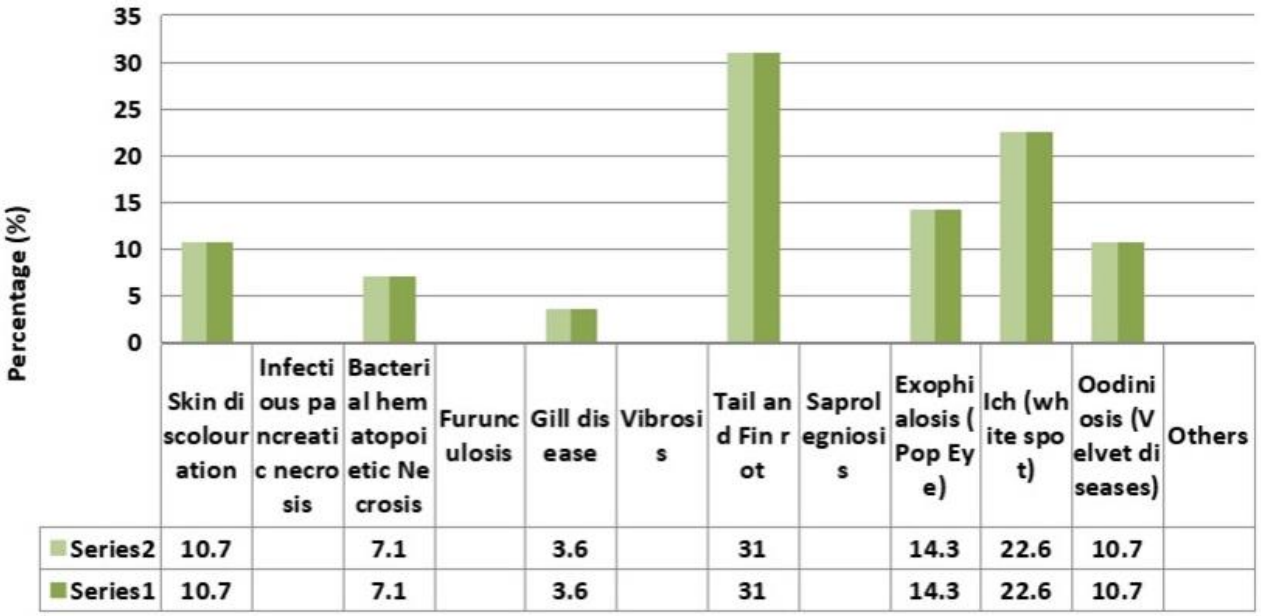

Figure 16. Types of Diseases affecting fishes of the respondents in the study area.

7.1% of fish farmers reported skin discolouration as a sign of fish disease affecting their fishes. 3.6% of fish farmers reported body itch as a sign of fish disease affecting their fishes. It was also noted that none of the farmers reported swollen bellies, loose buoyancy, red blood on skin, thick mucous in fish tanks and weak barbel as a sign of fish disease affecting their fishes, (0%) respectively. While every of the farmers tried to some extent to check for signs of fish disease affecting their fishes.

The result presented in Table 10 shows the response of the respondents in the study area regarding the number of fish affected by fish diseases. The result shows that 7.1% of fish farmers reported number of fish affected by fish diseases was between 22 – 32 fishes. 16.7% of fish farmers reported the number of fishes affected by fish diseases was between 11 and 21 fishes, 58.3% of fish farmers reported the number of fishes affected by fish diseases was 44 fish above, 11.9 % of fish farmers reported number of fishes affected by fish diseases were between 33 – 43 fishes. 6% of fish farmers reported number of fish affected by fish diseases was between 1 and 10 fish. It is also noted that no farmer was exempted from being affected by fish diseases, (0%).

From the research conducted, it was revealed that 31% of fish farmers reported tail and fin rot as the type of fish disease affecting the fish. 22.6% of fish farmers reported Ich (white spot), 14.3% of fish farmers reported Exophialosis (Pop Eye) as type of fish disease affecting the fishes. Some fish farmers reported skin discolouration, *Oodiniosis* (velvet diseases) and pealing of the mouth and tail (10.7%) as types of fish disease affecting their fish. 7.1% of fish farmers reported Bacterial hematopoietic Necrosis as type of fish disease affecting their fishes. 3.6% of fish farmers reported gill disease as a type of fish disease affecting their fish. It is also noted that none of the farmers reported Infectious pancreatic necrosis, *Furunculosis*, *Vibrosis* and *Saprolegniosis* as a type of fish disease affecting their fishes, (0%) respectively (Figure 16).

The biosecurity measures applied as regards vaccina-

Table 11. Distributions of the respondents according to vaccination of fish

Vaccination of Fish	Frequency	Percentage (%)
Yes	**0**	**0**
No	168	100
Total	168	100

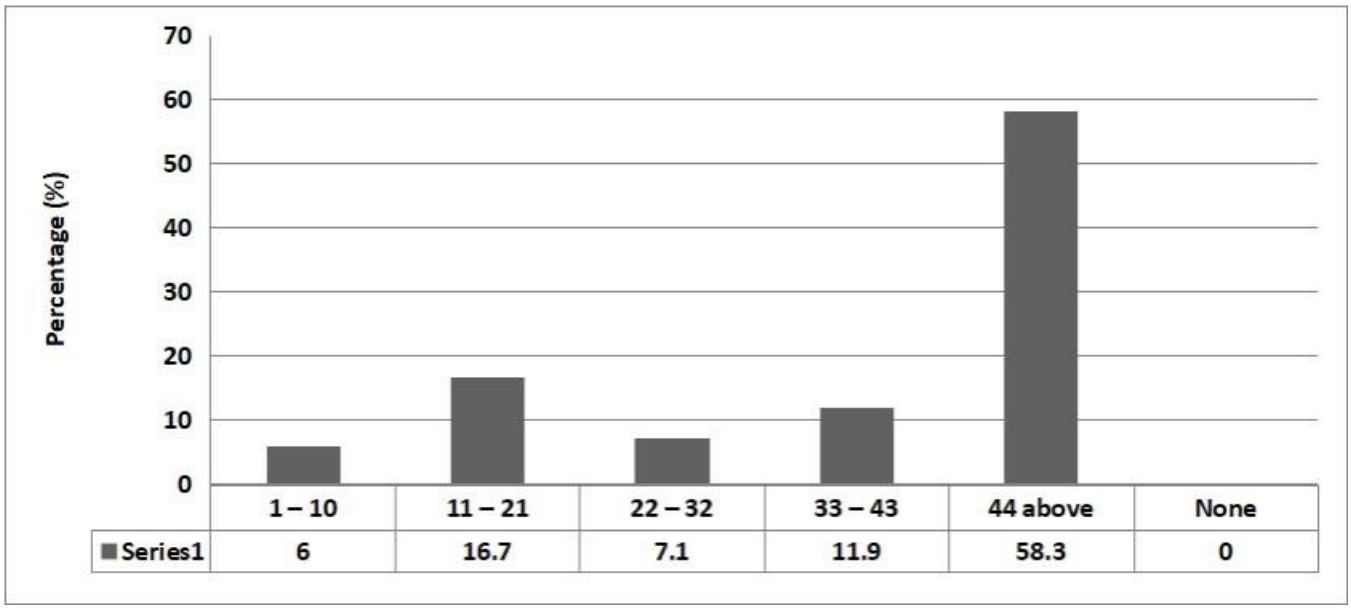

Figure 17. Mortality rate of fishes experienced by fish farmers in the study area.

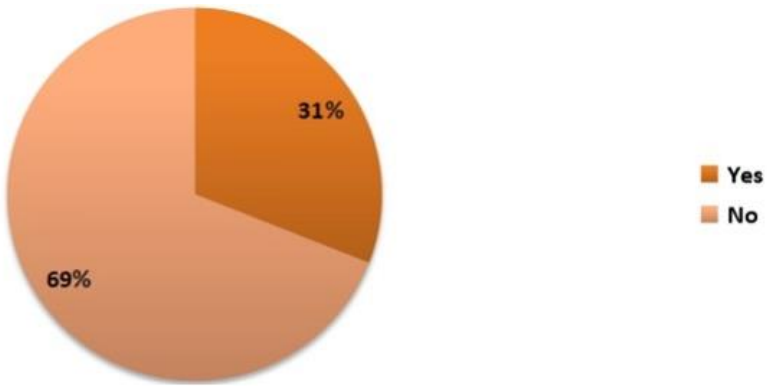

Figure 18. Showing disinfection of fish by fish farmers in the study area.

tion of fish by the fish farmers in the study area are illustrated in Table 11. It was revealed that 100% of the respondents in the study area do not vaccinate their fish.

Information collected from the survey showed the response of the respondents in the study area on fish mortality rate. The result shows that 58.3% of fish farmers reported fish mortality rate of 44 fishes above. 16.7% of fish farmers reported fish mortality rate of 11 – 21 fishes, 11.9 % of fish farmers reported fish mortality rate of 33 – 43 fishes. 7.1% of fish farmers reported fish mortality rate of 22-32 fishes. 6% of fish farmers reported fish mortality rate of 1 – 10 fishes. It is also noted that none of the farmers reported no fish mortality, (0%) (Figure 17).

The biosecurity measures applied as regards the disinfection of fish by the fish farmers in the study area are illustrated in Figure 18. It is revealed from the research conducted that 69% of the respondents in the study area do not disinfect their fish. While 31% of the fish farmers in

Table 12. Distributions of the respondents according to sanitizing hand before touring the facility.

Sanitizing hand before touring the facility	Frequency	Percentage (%)
Yes	**0**	**0**
No	168	100
Total	168	100

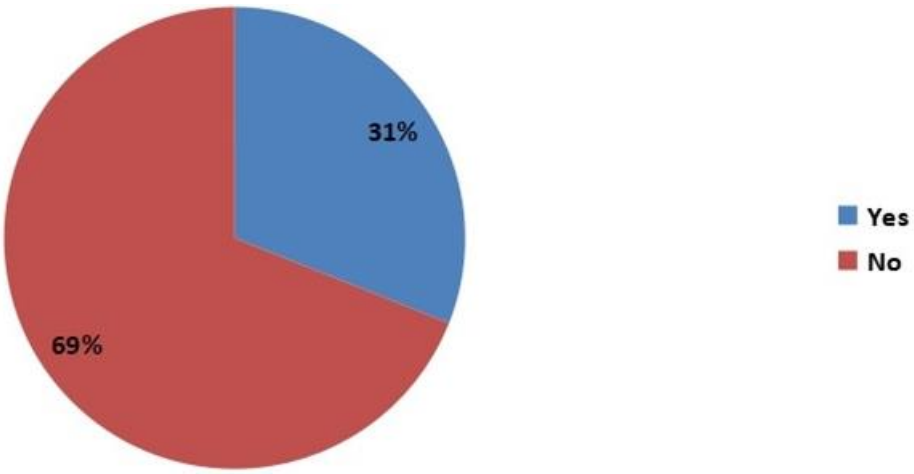

Figure 19. Showing designated meeting room for visitors by fish farmers in the study area.

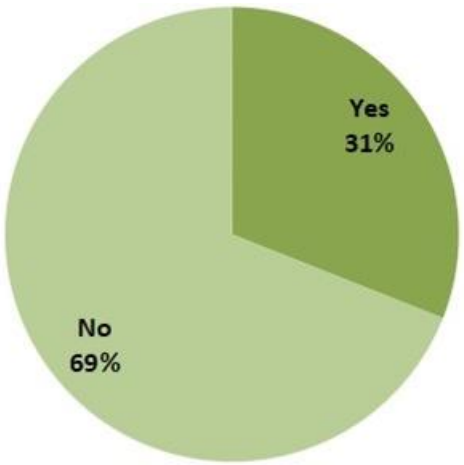

Figure 20. Showing recording of the numbers of fish coming into the farm by the fish farmers in the study area.

the study area disinfect their fish.

The biosecurity measures applied as regards the designated meeting room for visitors by the fish farmers in the study area are illustrated in Figure 19. From the research conducted, 69% of the respondents in the study area do not have designated meeting rooms for visitors on their farms. While 31% of the respondents in the study area have designated meeting room for visitors in their farm.

The biosecurity measures applied as regards hand sanitizing before touring the facility by the fish farmers in the study area are illustrated in Table 12. From the research conducted, 100% of the respondents in the study area do not sanitize their hands before touring the facility in the farm.

The biosecurity measures applied as regards recording the numbers of fish coming into the farm by fish farmers in the study area are illustrated in Figure 20. From the research conducted, 69% of the respondents in the study area do not record the number of fish coming into the farm. While 31% of fish farmers in the study area recorded the number of fish coming into the farm.

The biosecurity measures applied as regards recording of the numbers of fish going out of the farm by fish farmers in the study area are illustrated in Figure 21. It was revealed from the research conducted that 69% of the respondents in the study area do not record the numbers of fish going out of the farm. While 31% of fish farmers in the study area recorded the numbers of fish going out of the farm.

The biosecurity measures applied as regards recording of feeding behaviour of fish by fish farmers in the study area are illustrated in Figure 22. It was revealed from the research conducted that 69% of the respondents in the study area do not record the feeding behaviour of fish. While 31% of fish farmers in the study area have records of water quality parameters, checked record feeding

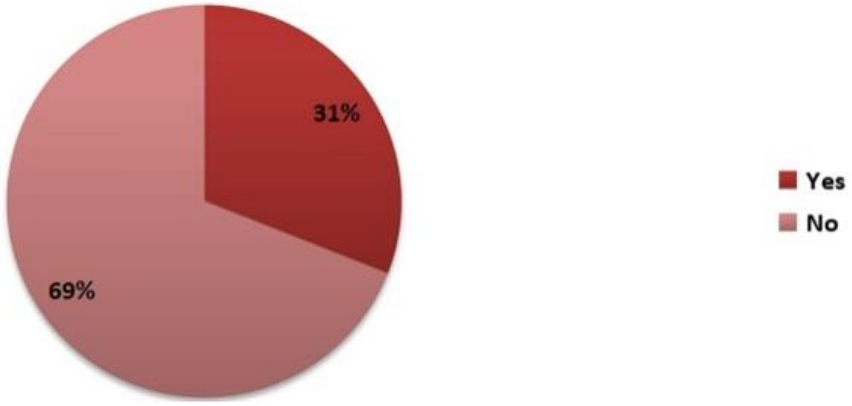

Figure 21. Showing recording of the numbers of fish going out of the farm farm by the fish farmers in the study area.

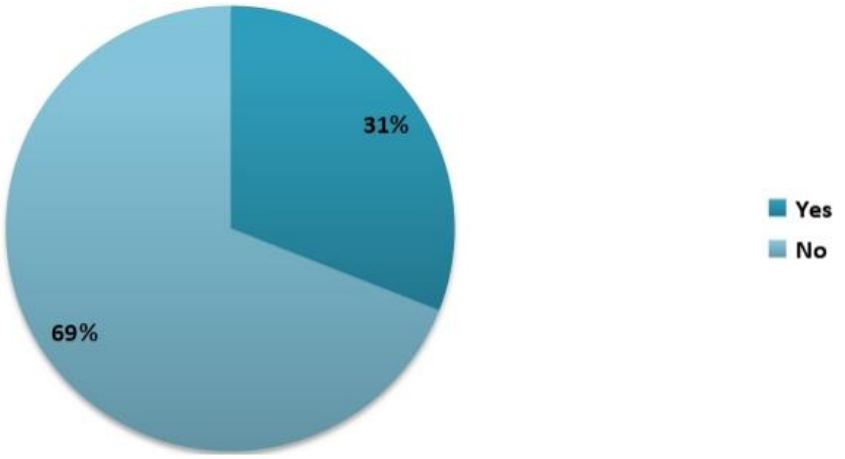

Figure 22. Showing recording of numbers of dead fish in holding tank farm by the fish farmers in the study area.

Table 13. Distributions of the respondents according to recording of other significant details relating to the health of the fish.

Recording of other significant details relating to the health of the fish	Frequency	Percentage (%)
Yes	**0**	**0**
No	168	100
Total	168	100

behaviour of fish.

The biosecurity measures applied as regards recording other significant details relating to the health of the fish by the fish farmers in the study area are illustrated in Table 13. From the research conducted, none of the respondents in the study area recorded the growth rate of fish or other significant details relating to the health of the fish.

The biosecurity measures applied as regards recording of feeding behaviour of fish by fish farmers in the study area are illustrated in Figure 23. It was revealed from the research conducted that 67.9% of the respondents in the study area do not record feeding behaviour of fish. While 32.1% of fish farmers in the study area have records of water quality parameters of the feeding behaviour of fish.

The biosecurity measures applied as regards recording of water quality parameters by the fish farmers in the study area are illustrated in Figure 24. It was revealed from the research conducted that 58.3% of the respondents in the

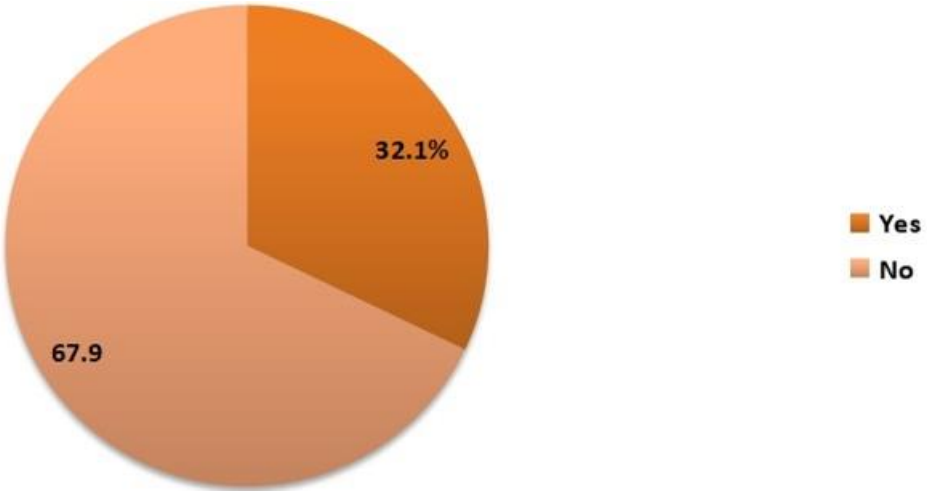

Figure 23. Showing recording of feeding behavior by fish farmers in the study area.

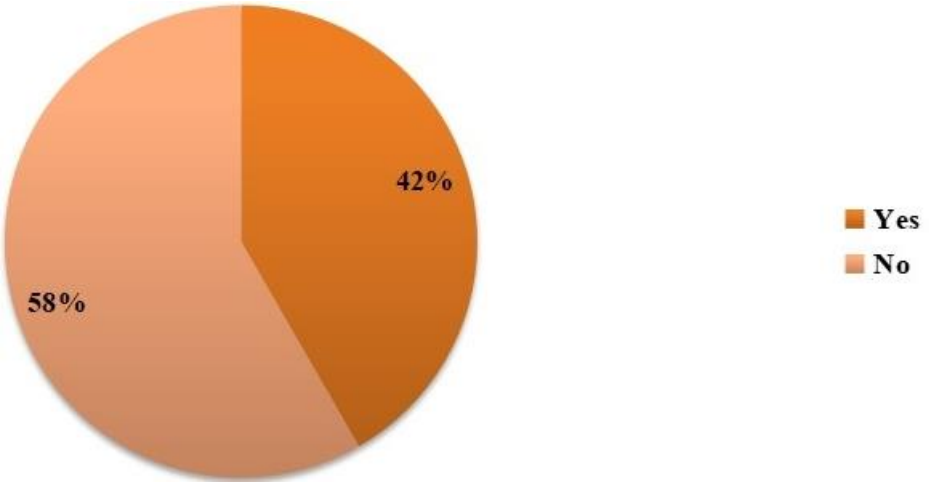

Figure 24. Showing recording of water quality parameters by the fish farmers in the study area.

study area do not have records of water quality parameters checked. While 41.7% of fish farmers in the study area have records of water quality parameters checked.

The biosecurity measures applied as regards possession of daily mortality record by the fish farmers in the study area are illustrated in Figure 25. It was revealed from the research conducted that 73% of the respondents in the study area do not have daily fish mortality record. While 26.8% of fish farmers in the study area have daily fish mortality records.

The biosecurity measures applied as regards recording of growth rate by the fish farmers in the study area are illustrated in Table 14. It was revealed from the research conducted that the respondents in the study area do not record growth rate of fish.

The biosecurity measures applied as regards recording of results of fish health inspection by fish farmers in the study area are illustrated in Figure 26. It was revealed from the research conducted that 81% of the respondents in the study area do not have a record of the results of fish health inspection. While 19% of fish farmers in the study area have a record of results of fish health inspection.

The biosecurity measures applied as regards provision for critical control points by setting up zones within apb (hatchery, fishery lakes, packing, processing, storage, and packaging) by the fish farmers in the study area are illustrated in Table 15. It is revealed from the research conducted that none of the respondents in the study area had provision for critical control points by setting up zones within apb (hatchery, fishery lakes, packing, processing, storage, and packaging) in their farms.

The biosecurity measures applied as regards provision of zone specific protective clothing by the fish farmers in the study area are illustrated in Table 16. It was revealed

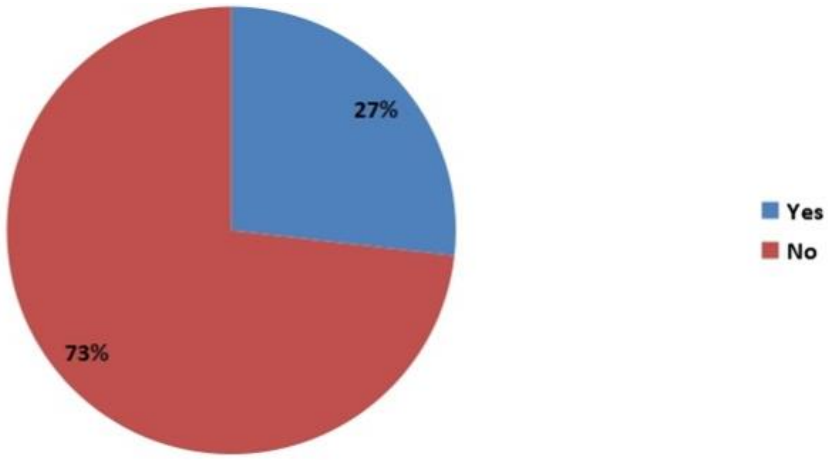

Figure 25. Showing possession of daily mortality record by the fish farmers in the study area.

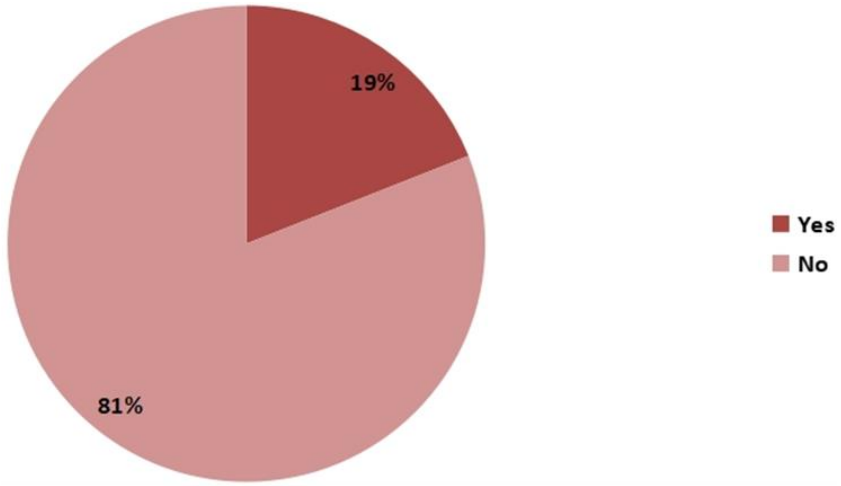

Figure 26. Showing recording of results of fish health inspection by the fish farmers in the study area.

Table 14. Distributions of the respondents according to recording of growth rate.

Recording of growth rate	Frequency	Percentage (%)
Yes	**0**	**0**
No	168	100
Total	168	100

Table 15. Distributions of the respondents according to critical control points by setting up zones within APB (hatchery, fishery lakes, packing, processing, stroage, and packaging).

Critical control points by setting up zones within APB	Frequency	Percentage (%)
Yes	**0**	**0**
No	168	100
Total	168	100

Table 16. Distributions of the respondents according to provision of zone specific protective clothing.

Provision of zone specific protective clothing	Frequency	Percentage (%)
Yes	**0**	**0**
No	168	100
Total	168	100

Table 17. Distributions of the respondents according to usage of colour coded boots.

Usage of colour coded boots	Frequency	Percentage (%)
Yes	**0**	**0**
No	168	100
Total	168	100

from the research conducted that none of the respondents in the study area had provision for zone-specific protective clothing in their farms.

The biosecurity measures applied as regards usage of colour coded boots by the fish farmers in the study area are illustrated in Table 17. It was revealed from the research conducted that none of the respondents in the study area used of colour coded boots in their farms.

DISCUSSION

The results evaluated the compliance of biosecurity measures in fish farms in four select communities (Uvwian, Orhuwhorun, Ugbisi and Kotokoto) in Udu Local Government Area of Delta State. Udu Local Government Area of Delta State have clusters of fish farms targeted towards providing employment for youths and adults in the region, food security and the eradication of poverty.

Objective one of this research set out to describe the socioeconomic characteristics of the respondents in the study area. The result shows that 58.3% of the respondents were male while 41.7% were female. This shows that fish farming is more attracted to male than female in the study area. The result reveals further that majority of the respondents are within ages 21 – 40 (35.7%). According to Monir *et al*. (2015), age is a key factor in the productivity and profitability performance of the farmer. It was observed that many of the fish farmers are still in their productive age which is in agreement with the work of Apata (2012).

Younger people tend to be more energetic, adjust faster, and adopt new technologies, thus may be more productive than the elderly who may be more conservative. Their involvement in the aquaculture industry will also ensure food security in the region and the nation as a whole. Pandey and Upadhayay (2012) reported that more participation of young and middle age group of peoples in fish production in the Tripuna (India). The work of Kumar *et al.* (2015) showed a shifting pattern from old age to young age which means that aquaculture is drawing the attention of the younger age bracket.

Data collected shows that the majority of the fish farmers in the study area have tertiary education 55.4%. Mignouna *et al*. (2011), Tommy *et al*. (2013) and Akoll and Mwanja (2012) reported that the education of the farmer is assumed to have a positive influence on farmers' decision to adopt new technology. Thus, education is important as a high literacy level will help fish farmers analyse and understand the rationale of using biosecurity measures. The study also revealed that the majority (50.6%) of the fish farmers in the study area are married. This means they have family responsibilities and should be committed to the biosecurity practices of their fish farms so as not to reduce their farm income and profits.

Objective two of this research examined the biosecurity measures adopted by fish farmers in the study area. The result from the study revealed that fish farmers in the study area have no awareness (67.9%) and understanding (58.9%) of bio-security (Figures 2 and 3). It is not surprising why fish farmer's level of compliance to biosecurity measures in the study area was poor. Biosecurity measures are very critical in preventing the entry of pathogens into farms (Assefa and Abunna, 2018). Therefore, lack of awareness and understanding of biosecurity measures poses a very serious problem and challenge whose impacts can be detrimental to the aquaculture sector, not only in the studied areas but also to the nation at large. The findings of this study on biosecurity are strikingly similar to the study in Uganda, which found a low level of diseases knowledge and awareness, some basic biosecurity measures being carried out in hatchers, but very few or no basic biosecurity measures are implemented routinely in grow-out farms (Børge, 2018). Figure 4 showed that 56.5% of fish farmers in the study area did not practice isolation of diseased fish.

On acclimatization of fish, the compliance was also poor as only 11.3% of fish farmers in the study area practised

acclimatization of fish, 23.8% practised partially while 64.9% did not practice at all (Figure 5). It was also seen from the research conducted that 77.4% of the respondents in the study area did not carry out a qualitative assessment of their fish feed (Figure 9) nor did they conduct proximate analysis of their fish feed (73.8%). This agrees with the report of Uhland *et al*. (2000).

Figure 16 revealed that 75% of the fish farmers in the study area dispose of dead fish in the production facility (pond) to be eaten by fish which is a deviation from biosecurity measures. This explains why a lot of fish were affected by fish diseases (Table 10) thus leading to a high rate of fish mortality (Figure 25). According to Fawzy *et al.* (2014), leaving dead aquatic animals in rearing infrastructure is a risk to public health and contributes to the spread of pathogens in the environment.

None of the fish farmers in the study area were found to use any vaccine on their fish (Table 12). This was obvious because the majority of the fish farmers in the study area were unaware of vaccines they could use on their fish. The use of vaccines does not prevent the introduction of pathogens. Delabbio (2004) however opines that vaccination of fish against a certain pathogen reduces the infectious load of the pathogen within a population and therefore reduces infection pressure on a population.

On disinfection of farm equipment and fish, Figure 18 revealed that 69% of fish farmers in the study area did not disinfect their farm equipment and fish. Disinfection prevents farm equipment from harbouring potential pathogens (Blanco *et al*., 2001). Post (1987) mentioned that fish pathogens can be transferred from holding unit to holding unit via the fish and rearing waters, and also on shared equipment and by personnel. Therefore, disinfection of farm equipment, hands and footwear to prevent transfer of disease pathogens is a commonly used biosecurity measure in farming enterprises (Torgersen and Hastein, 1995).

Objective three of this research compared the level of compliance and non-compliance to biosecurity measures in the study area. From the result of the chi-square (Table 18), there is no significant difference in the practice of isolation in compliance with biosecurity measures = x0.05. Therefore, fish farmers did not comply with biosecurity measures. This agrees with Lee and O'Bryen (2003) who reported similar findings.

Objective four identified the constraints affecting fish farmer's level of compliance to biosecurity measures in the study area. From the results obtained, the non-compliance of biosecurity measures in the study area is due to a lack of fish farm experience by fish farmers in the study area. From the survey conducted, 31% of fish farmers in the study area had between 2 – 4 years of fish farm experience (Table 6). The findings of Onyebinama (2004) state that previous experience in farm business management enables farmers to set realistic time and cost targets, allocate, combine and utilize resources efficiently and identify production risks. As farmers' years of farming experience increase, the probability of farmers having experience in disease management and other farm practices increases (Oluwatayo *et al*., 2008).

Contacts between neighbouring farms are quite frequent in the study area. These farms have very strong links with others and are intermediaries between all farms which creates biosecurity gaps. When appropriate biosecurity measures are not applied, these interactions expose fish farmers to the risk of the emergence and spread of health problems. These practices are contrary to FAO's (2012) biosecurity recommendations. Sharing water sources without prior analysis of physical, chemical, and microbiological quality are risk factor for the spread of pathogens on farms in the study area. This risk is cross-cutting because it concerns biosecurity measures that could be applied to equipment, fish, infrastructure, and workers. Scarfe *et al*. (2006) concluded in a study in Norway that the spread of salmon infectious anaemia was associated with proximity to farms that were in contact with the pathogen and at which biosecurity was poorly applied.

Conclusion

The results obtained from this study have shown that fish farming is an attractive enterprise engaged majorly by youths in the study area. Therefore, fish farming if well supported will have huge potential for the empowerment of the fish farmers in the study area. Biosecurity measures on aquaculture are poorly implemented in the study area. Simple practices such as quarantine, water quality management, qualitative analysis of feed, disinfection of equipment after use, use of work clothes for staff, management of access to the farm with a fence, visitor register, foot baths and the management of injured or sick fishes are poorly observed by the fish farmers. Therefore, there is a need for proper education for farmers on biosecurity measures compliance.

Recommendations

Based on these findings, the following recommendations are therefore proffered.

Fish pathologists and aquatic veterinarians as well as other aquaculture development agencies should strengthen technical assistance and extension services to farmers. Also, agencies like the Fisheries Society of Nigeria (FISON), and the State Department of Fisheries (SDF)) among others should strategically organize seminars, workshops, conferences and advisory services on the importance of biosecurity compliance for optimum production. Practices such as use of the same water source without prior physico-chemical, microbiological or parasitic analysis. The exchange of equipment in facilities and visitors' access to water and animals should be

prohibited. Fish farmers should also be encouraged to apply biosecurity measures at all stages of production. Aquaculture farms should have well-located and ready-usage sanitary facilities. They must include toilet and hand washing facilities. The installation of foot baths is also strongly recommended especially when farms receive visitors. Visitors should not have any contact with either the farm water used for aquaculture or the fish being raised. This is because these contacts can constitute a risk of the spread of zoonotic diseases. Practices such as wearing appropriate work clothes, and prohibiting all contact between people from outside the farm and fish will help to limit contamination from outside. The application of good biosecurity practices in aquaculture promotes animal welfare and high productivity.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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