Research Article

Catfish Farmers' Perception of Biosecurity Control Measures in Obio/Akpor Local Government Area, Rivers State, Nigeria

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Abstract | The study was carried out to assess the perception and level of biosecurity measures adopted by catfish farmers in Obio/Akpor District of Rivers State with respect to hatchery operations. Data was collected from 49 catfish farmers by interview and structured questionnaire. Descriptive statistics was used to analyze data obtained based on 4-point Likert scale. The result show that 81.63% of the catfish farmers had previous experience with eggs and fingerlings mortality. Majority of the respondents (81.63%) strongly agree that eggs mortality experienced in hatchery was due to fungal infection while 40.82% strongly agree that fungal infection was responsible fry/fingerlings losses in the hatchery. In general, the catfish farmers' perception of causes of eggs and fry/fingerlings mortality were positive (strongly agree or agree) on 6 items and negative on 5 other items. The respondents held positive position on 10 biosecurity measures including restriction of access, disinfection of facilities, use of malachite green, sodium chloride, lime, chlorine, antibiotics and self-prepared saline water. The study also show that specialized equipment were not used in transportation and palm oil and some chemicals were added to transportation medium as anti-stress. There is the need to train catfish farmers' on biosecurity measures and record keeping to further drive the growth of aquaculture production in Nigeria.

Keywords | Catfish hatchery, Biosecurity, Perception, Quarantine, Rivers State.

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INTRODUCTION

Nigeria is the leading aquaculture producing country in Sub-Saharan Africa, ranking second in the African continent after Egypt (Hinrichsen et al., 2022; FAO, 2020). The increase in aquaculture production are mainly due to increased investments in technology such as such as the use of extruded feed, water circulation systems, and improved farm management practices and catfish culture, notably the Clariids and their hybrids (Adewumi and Olaleye, 2017). The Clariid catfish are healthy food-fish that are hardy, low value and adapted to low aquaculture technology and high stocking density. Typically, the species is highly adaptable and tolerates poor water quality, a characteristic that enables them to stay out of water and poorly oxygenated water for long which lends its culture to traditional method in ponds and little expertise, thereby contributing to food security in Nigeria. Most of Clariid catfish produced in Nigeria now come from farming.

Hatchery bred Clariids in Nigeria are mainly *Clarias gariepinus*, *Heterobranchus longifilis* and *Heterobranchus bidorsalis* and the hybrid of *C. gariepinus* and *Heterobranchus species* which are induced to breed artificially in captivity. Despite the availability of other finfish species - *Oreochromis niloticus*, *Tilapia guineensis*, *Gymnarchus niloticus*, *Channa obscura*

and *Heterotis niloticus* - with huge potentials for culture, the Clariids have remained the major driving force behind increased aquaculture production in Nigeria due to their ease of management. Thus, Clariid hatchery is the most common type of fish hatcheries in Nigeria. They are nearly all private sector concerns carried out on small-scale basis (at homes, on-farms and small- to medium-scale) and their success in supplying fish farms with seed has contributed to the increase in national farmed fish production. The demand for food-fish in Nigeria has continued to soar in response to growing population. Subasinghe et al. (2021) estimate that to sustain the growth and meet the demand in catfish production, 683 million seeds would be needed by 2030, representing over 97% of 2019 demand. To meet demand for 683 million fry and fingerlings will require an increase in the numbers of on-farm, homestead, small- to medium-scale hatcheries or an expansion of existing large-scale hatcheries. The expansion and intensification of aquaculture such as is occurring in catfish production undoubtedly result in the emergence of new challenges - increased risk of emergence of new diseases and parasites and risk of disease transmission. To mitigate these emergent challenges and produce high quality and healthy fish seeds, there is the need to incorporate standard health management practices into production protocols. Sustainable aquaculture production is dependent on the application of standard hatchery protocols and practices that ensure steady availability of healthy and fast growing seeds for stocking production facilities or enhancement programmes.

Aquaculture biosecurity entails all the practices, procedures and policies deployed in a fish farm to prevent the introduction and spread of disease causing organisms. Against this background, the aim of this study was to assess the biosecurity knowledge of fish farmers with respect to hatchery operations in Obio-Akpor District of Rivers State, Nigeria. The results of this study can be used as a reference for the preparation of a national biosecurity programme to improve hatchery practices and aquaculture development in Nigeria.

MATERIALS AND METHODS

This study was conducted in Obio/Apor District of Rivers State, Nigeria. Rivers State is located in the Niger Delta region, lying within latitudes 4°45^{1}N and longitudes 6°50^{1}E. It is bounded on the South by the Atlantic Ocean. The name of the State derives from the numerous rivers of both freshwater and brackish waters crisscrossing the state which make her the ideal environment for aquaculture.

Population of study, Method of Data Collection and Analysis

The population of the study was made up of catfish farmers in Obio-Akpor District who were registered with the Rivers State Agricultural Development Programme (ADP). To determine the opinions and perception of catfish farmers' on fish hatchery biosecurity measures, a review of literature was carried out to select and create a list of biosecurity measures on the basis of which structured questionnaires was developed. The structured questionnaires were administered on 55 respondents to retrieve information from catfish farmers concerning perceived biosecurity practices or measures in the District. Biosecurity hatchery Practices were measured on a 4-point Likert scale of strongly agree = 4, agree = 3, disagree = 2 and strongly disagree = 1. Data analysis was performed on Statistical Package for the Social Science (SPSS). The information obtained were ordinal, therefore, percentage was used to explain the data. If the sum of Strongly agreed and agreed was above 50%, the overall response was regarded as positive perception and negative perception if the sum of disagree and strongly disagree response was above 50%. The opinion expressed was neutral if either sum was 50%. We also had one-on-one interview with some of the participants.

RESULTS AND DISCUSSIONS

This study aimed to assess how catfish farmers' in Obio-Akpor district of Rivers State understand biosecurity measures in catfish hatcheries as prophylaxis using structured questionnaires. Of the 55 questionnaires distributed 49 were returned, representing 89.09%.

Source of Brood-fish

Table 1 shows the different sources of brood-fish used in the hatcheries in the District. Majority of the farmers obtained brood-fish from other farms (79.2%) and 12.5% procured brood-fish from own farms.

Table 1: Sources of brood-fish used in the hatcheries in the District of Obio-Akpor, Rivers State, Nigeria

Source	No. of respondents	%
Imported or Foreign Clarias	3	6.25
Other farms	38	79.17
Own farm	6	12.50
Wild	1	2.08
Total	48	100

Durojaiye et al. (2020) reported that in Ijebu Ode region of the Southwest Nigeria, catfish brood-stock were mostly self-raised or sourced other farms with no source from the wild. Angahar (2017) reported similar trend in Makurdi, Nigeria where 89% of catfish producers' source Clariid

Table 2: Response (%) of catfish farmers' perception of some variable factors responsible for disease and mortality in catfish hatchery (N=48)

S/N	Variable Factor	SA %	AG %	DA %	SD %	Remarks
1	Disease very important factor in mortality	58.33	37.50	4.17	0	+
2	Poor Water quality the cause egg mortality	50.00	31.25	14.58	6.17	+
3	Fungal responsible for egg loss	83.33	8.33	6.25	2.08	+
4	Bacteria responsible for eggs loss	22.91	16.67	29.17	31.25	-
5	Parasites responsible for egg loss	10.42	16.67	50.00	22.91	-
6	Virus responsible for losses	8.33	31.25	31.25	29.17	-
7	Water quality the cause loss of fry and fingerlings	79.17	12.50	4.17	4.17	+
8	Fungal responsible for loss fry and fingerlings	41.67	20.83	6.25	31.25	+
9	Bacteria responsible for loss of fry and fingerlings	29.17	29.17	25.00	16.67	+
10	Parasites responsible for loss of fry and fingerlings	8.33	10.42	56.25	25.00	-
11	Viral issues for loss of fry and fingerlings	4.17	10.42	45.83	39.58	-

*Rem = remarks, + = positive perception and - = negative perception.

brood fish from other farms. Our result is also in tandem with Ibiwoye (2018) who reported that most catfish hatcheries in Nigeria (about 70%) source brood-stock from other farms and 21% obtain brood-stock from the wild and from other sources. The present study show that 52.1% of the respondents have records of the source of brood-stock while 47.9% do not have such records. Little et al. (2002) identified lack of record keeping with respect to the source, age and family line as a lingering challenge confronting brood-fish manage,ent and Ibiwoye (2018) notes that farms seling broodfish in Nigeria do not disclose the source of broodstock, including other important information. Thus, most brood-fish have been domesticated. Challenges of low productivity and unresponsiveness to culture conditions are associated with wild brood-stock of catfish.

Disease Occurrence and Mortality

The results show that catfish farmers have experienced mortality of eggs, fry and fingerlings. About 81.63% (for farm >1 yr. old) of the respondents had experienced mortality of eggs, fry and fingerlings while 18.36% (for farms < 1 yr. old) have not had any experience. As seen in Table 2 and Figure 1, majority of the catfish farmers in Obio-Akpor District of Rivers State either strongly agree (57.14%) or agree (38.78%) that diseases are important factors of mortality in hatchery. Remarkably, 81.63% of the respondents strongly agree (8.16 % agree, 8.16% disagree and 2.04% strongly disagree) that fungal infections were responsible for egg losses in the hatchery. Moreover, 40.82% of the catfish farmers' strongly agree (while 20.41% agree, 8.16% disagree and 30.61% strongly disagree) that fungal attacks were responsible for fry/fingerlings losses in the hatchery. On the issue of water quality, most of the respondents either strongly agree (48.98%) or agree (30.61%) that water quality was responsible for mortality of eggs while 77.55% strongly agree and 14.29% agree that water quality could be responsible for loss of fry/fingerlings in hatcheries. Contrarily, most the respondents disagree (48.98% or 55.10%) that parasites could be responsible for mortality of eggs or fry/fingerlings, respectively. Therefore, from these results, it can be concluded that the general perception of catfish farmers towards variable factors that predispose a hatchery were positive on 6 items and negative on 5 (Table 2).

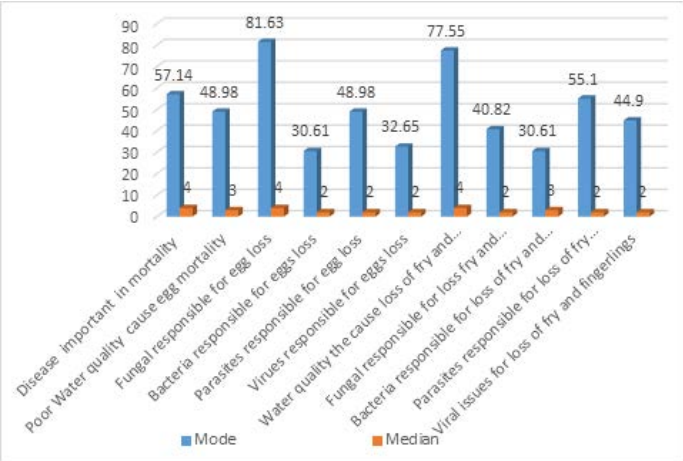

Figure 1: Catfish farmers' perception of causes of eggs and fry/fingerlings mortality in hatchery

Location of Hatchery/ Source of Water and Water Management System

The results show that majority of the respondents (95.8 %) have their fish farms located away from natural water source such as streams, rivers or channels while only 4.2% of the respondents had their farms located near natural water source. Location of hatchery is key in hatchery management. Hatcheries must be located away from natural sources of water to minimize interaction between escapees and wild fish, which can compromise the genetic integrity or germplassm of wild stock if they breed. Hatchery location also has implications for the management of waste water. Waste water from hatchery operations when

discharged into the environment cause eutrophication and pollution of the receiving water body and release offensive odours. Abdulkadir et al. (2017) made similar observation with respect to catfish hatcheries in the lower Niger Basin Area of Nigeria, making it important for 'fish farmers must obtain permits from relevant authorities before establishing fish hatcheries.

Table 3: Response (%) of catfish farmers' water management system in catfish hatchery (N=48)

Technology	Frequency	Percent
Mechanical aerators	3	6.25
Flow-through system	7	14.58
Stagnant water system	38	79.17
Total	48	100

Two source of water were identified by the respondents. Majority of the respondent accounting for 95.8% use borehole and rain water as the commonest source of water for operations. Only 4.8% source waters from streams/rivers. Our results is at variance with Adeleke et al. (2021) who reported 36% stream, 11% river, 35% groundwater/boreholes, and 20% rain catchment/reservoirs sources of water for aquaculture operations in Nigeria. The disparity may be due to the fact that Adeleke et al. (2021) considered the entire Nigeria with 774 Local Governments of which Obio-Akpor is just one in their study. Water source and quality play key roles in fish health and facility biosecurity. Interviews with some of the operators indicated that borehole water in the area is acidic and could result in high mortality. On how these have been managed, the respondent use CaCO3 to deal with situation. Furthermore, most farmers do have water testing kits. Only 6.25% of the respondents had water quality kits. George and Akinrotimi (2021) reported low level of awareness of water quality analysis as biosecurity measure among fish farmers some coastal communities of Rivers State, Nigeria. Whatever the source, we recommend that water for hatchery purpose must be screened for pathogens and analyzed to determine its fitness for the purpose since the hatchery phase in aquaculture operations is sensitive even to small changes in water quality – temperature, pH, mineral contents, and other contaminants.

Results also show that 81.3% of the respondents use flow-through system to manage water, 14.60% make use of stagnant water (change water after a period or do not change at all) and 4.2% deploy mechanical aerators. Aerators are used to optimize oxygen supply, however, unsteady power supply has limited its application in hatcheries in Nigeria and oxygen levels are monitored through virtual observation and through a constant flow-through system.

Record Keeping of Operations

Most of the catfish farmers have no records of their operations. Only 12.5% of the fish farmers kept records of visitors, hatching rates, mortality and water quality dynamics while, 87.5% never kept no records of operations. This is in agreement with a recent study by Omotesho et al. (2022) which reported low level of record keeping among farmers in Ekiti State, Nigeria. Good records of events in hatcheries are assets which can be used to avert diseases and improve fish health and ensure effectiveness of biosecurity programmes and profitability (Ali el., 2020; Faye et al., 2020; Adah et al., 2023). Thus, farmers must be trained to understand the place of record keeping in hatchery management and farm in general.

Biosecurity Measures

The perceptions of the fish farmers concerning hatcheries biosecurity measures were addressed using some listed activities or measures generally employed as biosecurity measures. The results (Table 4) showed that of all the biosecurity measures outlined, 8 were acknowledged as important and effective. One-half of the respondents were positively disposed to disinfection of eggs before fertilization. The practice of disinfecting eggs or fertilized products are not common; however, it is recommend where there is a high risk of contamination. The respondents have negative attitude towards submitting dead fish to veterinarians for diagnosis or post mortem (35.4% disagreed and 50.0% strongly disagreed). Moreover, 37.3% and 18.8% (or 56.1%) do not agree with burial or destruction of dead fish in the hatchery. Therefore, it is observed that the respondents have little knowledge about the importance of veterinary services, thus, the catfish farmers are not fully utilizing veterinary services. These results are consistent with Adah et al. (2023) in Nigeria and Ali et al. (2020) in Egypt. In general, the perception of the respondents were positive in restriction of visitors access (68.7%), disinfect all facilities during each cycle (72.9%), use of Malachite green to disinfect (64.6%), use of Salt to disinfect (72.9%), application of Chlorine to disinfect (54.2%), use antibiotics to prevent diseases (75%), preparation of own saline water (79.2%), and quarantining of brood-fish for 2-14 days (70.8%). On the other hand, placing foot dip (52.1%), use of Potassium permanganate to disinfect (52.1%), utilization of plant extracts to prevent and boast fish health (52.1%), diagnosis of cause of death by inviting a veterinarian (85.4%), availability of special quarantine tanks or ponds (54%) and keeping the brood-fish beyond 14 days before use (75%) elicited disagree and strongly disagree response. In aquaculture malachite green, formalin and sodium chloride are used as fungicide. However, despite the ban on the use of malachite green in aquaculture because of genotoxic and potential carcinogenic implications, it is still applied in Nigerian for brood-stock and egg disinfection (Adeyemo et al., 2011) and farmers' must be discouraged from using

Table 4: Response (%) of catfish farmers to Biosecurity Measures Considered Important in Obio-Akpor District of Rivers State for Catfish Hatcheries (N=48)

Biosecurity Measure	Percentage of Respondents				
	SA	AG	DA	SD	Rem
1. Disinfect eggs before fertilization	22.92	27.08	41.67	8.33	N
2. Restriction of visitors access	33.33	35.42	25.0	6.25	+
3. Place foot Dip	12.5	35.42	25.0	27.08	-
4. Disinfect all facilities	52.08	20.83	18.75	8.33	+
5. Potassium permanganate to disinfect	12.5	35.42	25.0	27.08	-
6. Malachite green to disinfect	33.33	31.25	25.0	10.42	+
7. Salt to disinfect	37.5	35.42	14.58	12.5	+
8. Lime to disinfect	25.0	18.75	37.5	18.75	-
9. Chlorine to disinfect	14.58	39.58	33.33	12.5	+
10. Use Antibiotics to prevent diseases	39.58	35.42	18.75	6.25	+
11. Plant extracts to prevent and treat fish	25.0	22.92	39.58	12.5	-
12. Purchase saline water	25.0	22.92	43.75	8.33	+
13. Prepare own saline water	22.92	56.25	20.83	-	+
14. Cause of death diagnosed by inviting a veterinarian	10.42	4.17	35.42	50.0	-
15. Dead individuals are either buried or destroyed	16.67	25.0	20.83	37.50	-
Quarantine period					
16. Availability of Special quarantine tanks or ponds	20.83	25.0	14.58	39.58	-
17. Keep brood fish from another farm for ≥ 2-14 days	37.50	33.33	16.67	12.50	+
18. Use immediately	14.58	29.17	37.50	18.75	-
19. Keep brood fish from another farm for between 14 days – 21 days	14.58	10.42	27.08	47.92	-

*Rem = Remarks, + = positive perception, - = negative perception, N= neutrality

Table 5: Response (%) of catfish farmers to transportation practices in Obio-Akpor District of Rivers State for Catfish Hatcheries (N=48)

Variables	Percentage of Respondents				
	SA	AG	DA	SD	Rem
Starve fish before transport	43.75	27.08	25.0	2.08	+
Open container	60.42	25.0	12.50	2.08	+
Close Container	20.83	31.25	39.58	8.33	+
Specialized	8.33	37.50	27.08	27.08	-
Private car	22.92	47.92	16.67	12.5	+
Public transport	41.67	39.58	18.75	-	+
Add palm oil to reduce foam	45.83	31.25	16.67	6.25	+
Salt/chemical to reduce stress	45.83	29.17	14.58	10.42	+

*Rem = Remarks, + = positive perception, - = negative perception

the chemical. Different plant extracts including *Vernonia amygdalina* commonly called bitter leaf and *Moringa oleifera* among others have been tested to understand their effect as disinfectants and prophylactic agents (Dandi et al., 2022; Gbadamosi et al., 2017). More research in this direction must be encouraged.

In an interview with some of the farmers, dead individuals were often left to be eaten up by individuals. This practice is not only a potential source of infection but pollutes the water, binds up oxygen and releases offensive odour. With respect to quarantining of the brood-fish, the farmers' displayed negative perception towards having quarantine tanks (Table 4). While 20.8% strongly agree and 25.2% agree on the provision of special quarantine tanks or ponds, 14.6% (disagreed) and 39.4% (strongly disagreed). The farmers did not support immediate use of brood-fish obtained from other farms according to 56.1% of the re-

spondents. In general, the very low level of compliance to biosecurity strategies reported by George and Akinrotimi (2021) in Asari-Toru LGA and Degema LGA of Rivers State do not agree with our result.

Transportation practices

Table 5 shows the common transportation practices associated with hatchery. Most of the farmers (43.8% strongly agree and 27.1% agree) with starvation of fish (brood-fish and fingerlings) before embarking on transporting them. Most of the respondents use open containers (60.4% strongly agree and 25% agree). Some 20.8% and 31.3% strongly agree and agree, respectively on the use of closed containers in transportation of fish. To deal with stress associated with transportation, most catfish farmers add Salt/ other chemicals (45.8% and 29.2% strongly agree and agree, respectively) and palm oil (45.8% and 31.3% strongly agree and agree, respectively) to the transporting medium.

The purpose of good transportation practices were to deliver healthy fingerlings and sufficiently reduce stress and maintain appearance. Several chemicals are added to the transportation medium to maintain the integrity of transported fingerlings, reduce stress and reduce mortality (Swann, 1993, Crosby et al., 2006). Falaye et al. (2012) noted that addition of palm oil at the varying concentrations kept the freshness of the fish during transportation thereby improving the market value of transported live catfish. Transport brood fish in well oxygenated, sealed tanks with plenty of room for movement.

CONCLUSION

The study assessed perception of biosecurity in hatcheries by catfish farmers in Obia-Akpor Local Government Area of River State, Nigeria. The study provided valuable information on the opinion of catfish farmers on biosecurity measures in catfish hatcheries. Farmers recognized eggs and fingerlings mortality as important factors in fish hatchery and identified fungal, bacterial and water quality related issues as causes of mortality. Moreover, restriction of visitors access, disinfection using Malachite green, Salt and Chlorine, use antibiotics to prevent diseases, preparation of own saline water, and quarantining of brood-fish for 2-14 days were identified as most important biosecurity measures. Governments at all levels in Nigeria and regulatory agencies must move in quickly to mop up noxious substances used in fish production such as malachite green. In our opinion, catfish farmers' view of biosecurity measures are inadequate and would not likely prevent an outbreak. The poor level of awareness of record keeping makes training of the farmers on different aspects of biosecurity urgent and compelling. It important that catfish farmers establish biosecurity protocols in hatchery facilities to prevent or curb the introduction and spread of disease within or between hatchery facilities. The result of this research could be a guide to government and professional groups in designing effective biosecurity program or Best Management Practices for hatchery operators.

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Thanks to catfish farmers whoprovided answers to our questions.

CONFLICT OF INTEREST

We declare that there is no conflict of interests regarding the publication of this article.

NOVELTY STATEMENT

The study is unique and provides farmers perspectives on biosecurity. It adds to existing knowledge on the issue.

AUTHORS CONTRIBUTIONS

Both authors contributed equally to the article. Nwafili designed the questionnaire, analysed the data and discussed the findings.

REFERENCES

Abdulkadir J.O., Sadiku S, Tiamiyu L.O. (2016). Environmental impact assessment of fish farm hatcheries management in lower Niger Basin Area of Nigeria. VJ. Agricult. Res. Develop., 15(2): 110-125. https://doi.org/10.4314/jard.v15i2.11

Adah D.A., Saidu L., Oniye S.J, Adah A.S. (2023). An assessment of the impacts of biosecurity measures on mortality of fish from fish farms. Aquacult. Stud., 23(5). https://doi.org/10.4194/AQUAST1060

Adeleke M.L., Al-Kenawy D., Nasr-Allah A.M., Dickson M., Ayal D. (2021). Impacts of Environmental Change on Fish Production in Egypt and Nigeria: Technical Characteristics and Practice. In: Oguge, N., Ayal, D., Adeleke, L., da Silva, I. (eds) African Handbook of Climate Change Adaptation. Springer, Cham. https://doi.org/10.1007/978-3-030-45106-6_153

Adewumi A. A., Olaleye V. F. (2017). Catfish culture in Nigeria: Progress, prospects and problems. Adv. J. Environ. Sci. Technol., 8 (2): 001-005,

Adeyemo O.K., Alarape S.A, Emikpe B.O (2011). Reprotoxic Effect of Malachite Green on African Catfish *Clarias gariepinus* (Burchell 1822). J. Fisher. Aquat. Sci., 6: 563-570 https://doi.org/10.3923/jfas.2011.563.570.

Ali S.E., Jansen M.D., Mohan C.V., Delamare-Debouteville J., Charo-Karisa H. (2020). Key risk factors, farming practices and economic losses associated with tilapia mortality in Egypt. Aquaculture (Amsterdam, Netherlands), 527:

735438. https://doi.org/10.1016/j.aquaculture.2020.735438

Angahar L.T. (2017). Production of Clariid Brood stock in Makurdi: Status, Constraints and Implications on Aquaculture in Nigeria. J. Adv. Botany Zool.

Crosby T.C, Hill J.E, Martinez C.V, Watson C.A, R.P. E. Yanong, (2006). On-farm transport of Ornamental fish. (FA – 119) University of Florida IFAS Extension http://edis.ifas.uf/.edu https://doi.org/10.32473/edis-fa119-2006

Dandi S.o., Abarike E.D., Yeboah A.A. (2022). Bitter Leaf *Vernonia amygdalina* Extract Enhances Growth, Hematology, Heat Stress Response, and Resistance to *Aeromonas hydrophila* in Nile Tilapia. North American J. Aquacult., 84(4): 432-441. https://doi.org/10.1002/naaq.10256

Durojaiye T.A., Ojetayo S. O. Sule , T. E. Balogun,. Akintuyole A. S. (2020). Incidence of Diseases in Fish Hatcheries and Control Measures Adopted by Fish Farmers in Ijebu-Ode Region, Ogun State, Nigeria. Trends Sci. Technol. J., 5(1): 083 – 086.

Falaye E., Omoike A., Folorunso L. A, Bello O.S. (2012). The Effects of Palm Oil on the Physical Appearance of *Clarias gariepinus* during Transportation. Int. J. Plant, Anim. Environ. Sci., 2(4): 82-89.

FAO (2020). The state of world fisheries and aquaculture 2020. Sustainability in action. Rome. https://doi.org/10.4060/ca9229en

Faye R., Diouf N.D., Amadou LY, M Ayih-Akakpo J.A (2020). Biosecurity practices applied in aquacultural farms in northern Senegal, West Africa. Euro. Scient. J., 16(6): 287-300. https://doi.org/10.19044/esj.2020.v16n6p286

Gbadamosi O, Fasakin E, Adebayo T (2017). Hepatoprotective and stress - reducing effects of dietary *Moringa oleifera* extract against *Aeromonas hydrophila* infection and transportation-induced stress in African catfish (*Clarias gariepinus*) (Burchell, 1822) fingerlings. Livest. Res. Rural Develop. Volume 29, Article #23. Retrieved November 27, 2022, from http://www.lrrd.org/lrrd29/2/ejay29023.htm

George A.D.I., Akinrotimi O.A. (2021). Socioeconomic characteristics and biosecurity measures among fish farmers in some coastal communities of Rivers State, Nigeria. Int. J. Res and Sc. Innov. VIII(1):190-193.

Hinrichsen E, Walakira JK., Langi S., Ibrahim NA., Tarus V., Badmus O., Baumüller H (2022). Prospects for aquaculture development in Africa: A review of past performance to assess future potential, ZEF Working Paper Series, No. 211, University of Bonn, Center for Development Research (ZEF), Bonn, https://nbn-resolving.de/urn:nbn:de:101:1-202202100155593583879O

Ibiwoye Y. E (2018). Assessment of broodstock management practices in Nigeria. United Nations University Fisheries Training programme, Iceland final project. http://www.unuftp.is/static/fellows/document/Yetunde17prf.pdf https://doi.org/10.24940/ijird/2018/v7/i8/AUG18061

Little D. C., Satapornvanit A., Edward P. (2002). Freshwater Fish seed in Asia. p 185 - 196. In Rural Aquaculture. Wallingford: CABI Publishing. https://doi.org/10.1079/9780851995656.0185

Omotesho K.F., P.A. Fatodu, T.B. Ajibade. (2022). Farm record keeping behaviour of rural farming youths in Ekiti State, Nigeria. Sarhad J. Agricult., 38(1): 92-102, https://doi.org/10.17582/journal.sja/2022/38.1.92.102

Subasinghe R, Siriwardena S.N, Byrd K, Chan CY, Dizyee K, Shikuku K, Tran N, Adegoke A, Adeleke M, Anastasiou K, Beveridge M, Bogard J, Chu L, Fregene BT, Ene-Obong H, Cheong KC, Nukpezah J, Olagunju O, Powell A, Steensma J, Williams G, Shelley C and Phillips M. (2021). Nigeria fish futures. Aquaculture in Nigeria: Increasing Income, Diversifying Diets and Empowering Women. Report of the scoping study. Penang, Malaysia: WorldFish. Program Report: 2021-16.

Swann L.(1993). Transportation of fish in Bags. North Central Regional Aquaculture Centre also in University of Missouri Extension Live and Learn MX 392.