



Breeding and Broodstock Management Practices among Catfish Hatchery Operators in Kogi State, Nigeria

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Abstract

The sustainability of aquaculture development in Nigeria largely depends on the availability of high-quality fish seed, which is influenced by breeding and broodstock management practices at the hatchery level. This study assessed breeding practices, broodstock sourcing and characteristics, artificial propagation techniques, and health management practices among catfish hatchery operators in Kogi State, Nigeria. A stratified sampling technique was used to select 132 hatchery operators across nine Local Government Areas in the three senatorial districts of the state. Primary data were collected using structured questionnaires and analyzed using descriptive and inferential statistics. The results showed that 56.1% of respondents had received training in fish breeding, with empowerment programmes being the major source of training. Crossbreeding (56.8%) and artificial propagation (65.9%) were the dominant breeding approaches. Most operators sourced broodstock from fish farms (54.5%) and identified them primarily using sex organs (79.6%), with little use of standardized identification methods. Broodstock were generally of moderate size (2-2.5 kg) and relatively young (10-11 months). Milt extraction was predominantly carried out by sacrificing male fish (84.1%), while synthetic hormones such as ovatide (37.9%) and ovulin (34.1%) were widely used for induced spawning. Most hatcheries produced juveniles (49.2%), reflecting a preference for larger seed sizes. Water for hatchery operations was mainly sourced from rivers (44.7%) and boreholes (40.9%), with aeration (64.4%) being the principal water quality management practice. Although over half of the operators monitored water quality daily, the use of filtration systems and diagnostic facilities was limited. Bacterial infections (40.2%) were the most commonly reported diseases, and medication (58.3%) was the predominant health management strategy. The study concludes that while hatchery operators in Kogi State have adopted key artificial propagation techniques, significant gaps exist in broodstock management, genetic improvement, water quality control, and disease prevention. Strengthening technical capacity, promoting structured breeding programmes, improving hatchery infrastructure, and enhancing preventive health management practices are essential for improving fish seed quality and ensuring sustainable aquaculture development.

Keywords:

Breeding, Broodstock Management Practices, Catfish Hatchery Operators, Kogi State.

1.0 Introduction

Aquaculture has been widely recognized as the fastest-growing segment of global animal food production, contributing significantly to the global fish supply at a time when capture fisheries are increasingly threatened by overfishing and resource depletion (Food and Agriculture Organization, 2021). The sector now accounts for more than half of global fish production and continues to expand as demand for affordable, high-quality animal protein rises, particularly in developing countries (FAO, 2016). For instance, global farmed tilapia production reached approximately 6 million metric tons in 2019, while farmed catfish production exceeded 5.5 million metric tons in 2017 (FAO, 2021; FAO, 2019). Beyond its contribution to food supply, aquaculture plays a crucial role in supporting livelihoods, generating employment, and enhancing economic development, especially in regions where access to alternative protein sources is limited (Nwakuche *et al.*, 2019). With over 424 aquatic species currently under cultivation worldwide, the sector continues to provide significant benefits in terms of food security, nutrition, and poverty reduction (Galappaththi *et al.*, 2020).

In Nigeria, aquaculture has become an essential component of the national food system, largely driven by the decline in capture fisheries resulting from overfishing, environmental degradation, and habitat loss (Adedeji *et al.*, 2011). The country remains a leading aquaculture producer in sub-Saharan Africa, contributing about 40.5% of the region's output and producing approximately 307,000 metric tonnes annually (FAO, 2020). This growth has been fueled by both government support and increasing private sector investment, with fish farming operations dominated by catfish species (*Clarias* and *Heterobranchus*) and tilapia. However, the sustainability of this growth is closely tied to the consistent availability of high-quality fish seed, which forms the foundation of successful aquaculture production systems.

Fish seed production has increasingly shifted from dependence on natural water bodies to hatchery-based systems due to the decline in natural spawning grounds and ecological disturbances (Bluwey *et al.*, 2018). Artificial propagation techniques, particularly hormone-induced breeding, have enabled year-round production of fish seed and improved hatchery efficiency (Moehl *et al.*, 2006). Despite these advancements, the supply of high-quality fingerlings in Nigeria remains inadequate, with demand consistently exceeding production capacity (Fawole *et al.*, 2020). This imbalance has led many hatchery operators to prioritize quantity over quality, resulting in substandard seed with poor growth performance and survival rates (Araujo *et al.*, 2022). Furthermore, the absence of structured broodstock management systems and the lack of a functional broodstock bank have contributed to the widespread use of broodfish of unknown genetic origin, increasing the risk of inbreeding and genetic deterioration within hatchery populations (Araujo *et al.*, 2022).

The problem is further compounded by inadequate adoption of improved hatchery management practices and weak biosecurity systems within the Nigerian aquaculture sector. Compared to leading aquaculture nations in Africa, Nigeria continues to rely heavily on rudimentary production systems, limited technical capacity, and poorly coordinated extension services (FAO, 2020). As a result, hatcheries often experience high mortality rates, disease outbreaks, and inconsistent seed quality, which collectively constrain productivity and limit the sector's ability to meet growing domestic demand. These challenges are closely linked to issues such as poor broodstock sourcing, ineffective breeding practices, and inadequate disease control measures, all of which directly influence hatchery performance and overall aquaculture sustainability.

At the sub-national level, Kogi State possesses significant potential for aquaculture development due to its abundant water resources and increasing participation in fish farming activities. However, the sector continues to face challenges related to poor seed quality, inadequate breeding practices, and limited technical capacity among hatchery operators. Reports of stunted growth, poor feed conversion efficiency, and high mortality rates in cultured fish have been associated with suboptimal hatchery management and weak application of genetic improvement strategies (Ndashe *et al.*, 2023). Additional constraints, including poor larval nutrition, high early-stage mortality, and limited access to quality inputs, further exacerbate the problem (Gisbert *et al.*, 2022). Although several studies have examined aquaculture practices in other parts of Nigeria, there is a paucity of empirical data specifically addressing breeding and broodstock management practices in Kogi State, thereby limiting the development of targeted interventions for the region.

In view of these challenges, there is a need for a comprehensive assessment of breeding and broodstock management practices among catfish hatchery operators in Kogi State. This study therefore aims to investigate the prevailing practices related to fish breeding, broodstock sourcing, hatchery management, hormone usage, and disease control, with the objective of identifying gaps and opportunities for improvement. The findings are expected to provide evidence-based insights that will enhance fish seed quality, improve hatchery productivity, and support the sustainable development of aquaculture in the study area.

2.0 Materials and Methods

2.1 Study Area

The study was conducted in selected Local Government Areas (LGAs) of Kogi State, Nigeria. Kogi State, popularly referred to as the “Confluence State,” is located in the North-Central region of the country, where the River Niger and River Benue meet in the state capital, Lokoja. The state lies between latitudes 6°30'N and 8°48'N and longitudes 5°23'E and 7°48'E, and is bounded by Ekiti and Kwara States to the west, the Federal Capital Territory to the north, Nasarawa State to the northeast, Niger State to the northwest, Edo and Ondo States to the southwest, Anambra and Enugu States to the southeast, and Benue State to the east. Kogi State was created on 27 August 1991 from parts of Benue, Niger, and Kwara States (Onyeakagbu, 2021).

The state is endowed with abundant water resources and favorable climatic conditions that support aquaculture development. Its economy is predominantly agrarian, with major crops including coffee, cashew, groundnut, cocoa, oil palm, and yam, alongside livestock production and extractive industries such as coal and mineral mining (Akanbi, 2021). These characteristics make Kogi State a suitable location for assessing hatchery-based fish production practices.

2.2 Sampling Procedure and Data Collection

A stratified sampling technique was employed to ensure adequate representation across the three senatorial districts of Kogi State: Kogi East, Kogi Central, and Kogi West. From each district, three LGAs with notable aquaculture activities were purposively selected based on their prominence in fish farming as identified from secondary sources (Oyewole *et al.*, 2023). The selected LGAs included Ankpa, Dekina, and Idah (Kogi East); Okene, Okehi, and Ajaokuta (Kogi Central); and Lokoja, Kabba/Bunu, and Kogi (Koton-Karfe) (Kogi West).

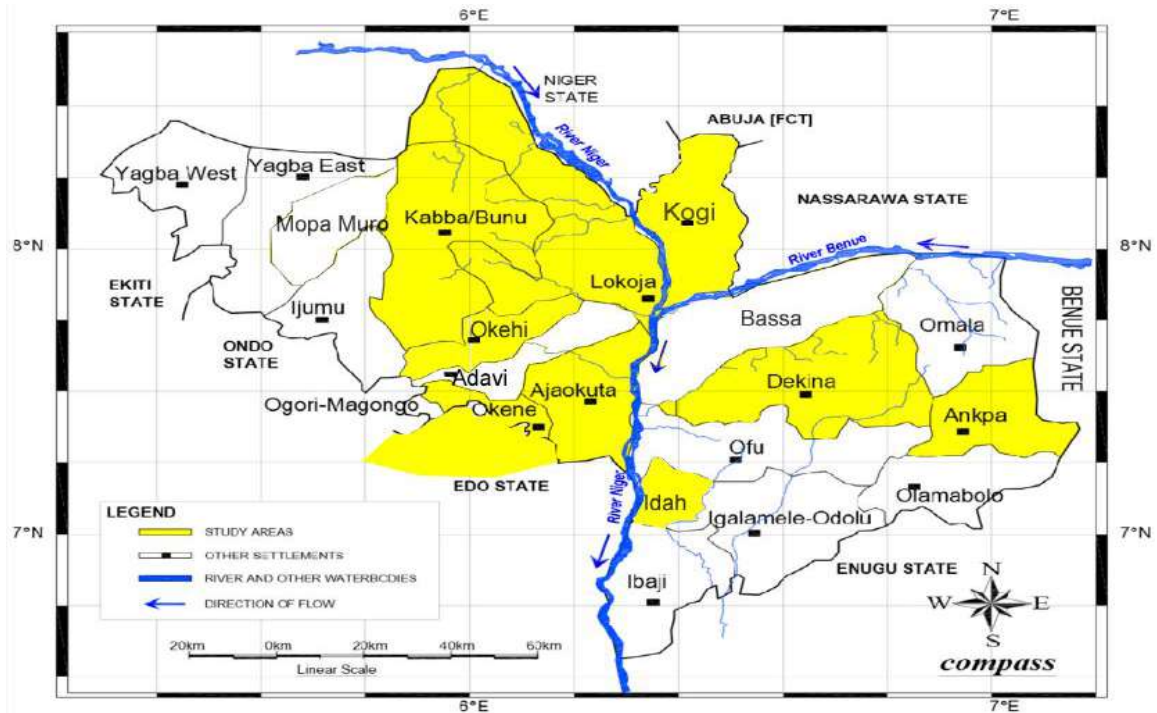


Figure 1: Map of Kogi State indicating the selected LGA's included in the study.

Within each LGA, fifteen (15) hatchery operators were randomly selected, resulting in a total sample size of one hundred and thirty-two (132) respondents. Primary data were collected through structured questionnaires complemented by scheduled interviews with fish hatchery operators. The instruments were designed to capture information relevant to the objectives of the study, including breeding practices, broodstock sourcing and management, hatchery techniques, hormone usage, fry management, and disease control practices.

2.3 Data Analysis

Data collected from the field were analyzed using descriptive statistical methods. Frequencies, percentages, and means were used to summarize variables related to breeding practices, broodstock management, hatchery operations, and health management practices among respondents. The results were presented in tables for clarity and ease of interpretation. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 26.

3.0 Results and Discussion

3.1 Capacity, Breeding Practices and Hatchery Operations

The results in Table 3.1 reveal that slightly more than half of the hatchery operators (56.1%) had received formal training in fish breeding, while a considerable proportion (43.9%) had no training. Among those trained, most acquired their knowledge through empowerment programmes (43.18%), followed by university education (34.09%), and to a lesser extent through self-learning platforms such as YouTube (22.73%). This pattern suggests a moderate level of technical capacity within the study area, largely driven by institutional and intervention-based efforts. Similar trends have been reported in other parts of Nigeria, where training and extension services significantly influence hatchery performance, although gaps in technical

expertise persist due to limited access and high costs of training (Nwafili and Uchechi-Ibinabo, 2023; Digun-Aweto and Oladele, 2017).

Table 3.1: Capacity, Breeding Practices, and Hatchery Operations among Catfish Hatchery Operators in Kogi State, Nigeria.

Variable	Frequency	Percent
Training in fish breeding		
Yes	74	56.1
No	58	43.9
Total	132	100
Training Details		
Empowerment program	57	43.18
University	45	34.09
YouTube Videos	30	22.73
Total	132	100
Breeding practices		
Selection	13	9.8
Hybridization	25	18.9
Cross Breeding	75	56.8
Sex Reversal	4	3
Chromosome Manipulation	15	11.4
Total	132	100
Technology/method		
Natural propagation	13	9.85
Semi natural propagation	25	18.9
Artificial propagation	87	65.9
Natural and semi natural	6	4.55
Others	1	0.8
Total	132	100
Frequency of Spawning		
3-4 months	25	18.9
5-6 months	63	47.7
7-8 months	15	11.4
On noticing readiness of eggs	29	22
Total	132	100
Hatchery System		
Concrete	40	29.8
Tanks	47	35.9
Earthen pond	19	14.5
Others	26	19.8
Total	132	100
Breeding Location		
Open space in the farm	26	19.7
Any available tank	28	21.2
Fish hatchery	78	59.1
Total	132	100
Reasons for breeding practices		

Improved growth	74	56.1
Increase number	13	9.8
Increase income	22	16.7
Satisfy clients/buyers	23	17.4
Total	132	100

In terms of breeding practices, crossbreeding was the most widely adopted method (56.8%), followed by hybridization (18.9%) and chromosomal manipulation (11.4%), while selection (9.8%) and sex reversal (3.0%) were less commonly practiced. The dominance of crossbreeding and hybridization reflects a strong preference for combining desirable traits such as rapid growth and environmental tolerance, which aligns with observations in other aquaculture systems where farmers prioritize productivity and resilience (Srikulnath *et al.*, 2025; Manyise *et al.*, 2024). However, the relatively low use of selection-based breeding suggests limited implementation of structured genetic improvement programmes, a situation that has been linked to genetic deterioration and reduced performance in hatchery stocks (Ibiwoye and Thorarensen, 2018).

The predominance of artificial propagation (65.9%) further reinforces the shift towards controlled breeding systems in the study area, with fewer operators relying on semi-natural (18.9%) or natural methods (9.85%). This trend is consistent with reports that highlight the increasing adoption of hormone-induced breeding techniques to enhance seed production and ensure year-round availability of fingerlings (Kartina *et al.*, 2023). While artificial propagation improves production efficiency, its effectiveness is highly dependent on proper broodstock management and technical competence.

Spawning practices among respondents also showed variability, with nearly half (47.7%) carrying out spawning at intervals of 5-6 months, while others operated at shorter intervals of 3-4 months (18.9%) or based spawning on the readiness of eggs (22.0%). A smaller proportion (11.4%) reported longer intervals of 7-8 months. Frequent spawning without structured broodstock rotation or genetic planning has been associated with increased risks of inbreeding and reduced seed quality in aquaculture systems (Kwikiriza *et al.*, 2025; Ibiwoye and Thorarensen, 2018), suggesting potential implications for long-term productivity.

With respect to hatchery infrastructure, tanks (35.9%) and concrete systems (29.8%) were more commonly used than earthen ponds (14.5%), with some respondents utilizing other systems (19.8%). In addition, most breeding activities were conducted within dedicated hatchery facilities (59.1%), while others used available tanks (21.2%) or open spaces (19.7%). The preference for tanks and controlled hatchery environments reflects a broader transition towards more intensive and manageable production systems, particularly in areas with increasing commercialization of aquaculture (Kwikiriza *et al.*, 2025; Arif and Farikhah, 2025; Ashley-Dejo and Adelaja, 2022).

The primary motivation for adopting these breeding practices was improved growth performance (56.1%), followed by the need to satisfy customers (17.4%), increase income (16.7%), and increase production output (9.8%). These responses highlight the strong market-driven orientation of hatchery operations, where decisions are largely influenced by economic returns and consumer demand. Similar priorities have been reported among fish farmers in

Nigeria, where growth rate, survival, and market acceptance are key determinants of production strategies (Srikulnath *et al.*, 2025; Manyise *et al.*, 2024).

3.2 Broodstock Sourcing, Characteristics and Identification

The results presented in Table 3.2 show that broodstock identification among hatchery operators in Kogi State is largely based on observable biological traits. A substantial majority of respondents (79.55%) identified broodstock using the sex organ, while fewer relied on appearance (10.61%) and body shape (9.84%). Notably, none of the respondents reported the use of standardized fish identification keys.

Table 3.2: Broodstock Sourcing, Characteristics, and Identification among Catfish Hatchery Operators in Kogi State, Nigeria

Variable	Frequency	Percent
Broodstock identification method		
Sex organ	105	79.55
Appearance	14	10.61
Body shape	13	9.84
Use of fish identification keys	0	0
Total	132	100
Primary source of broodstock		
Wild	20	15.2
Fish farm	72	54.5
Gift	5	3.8
Grow out pond	35	26.5
Total	132	100
Average weight of broodstock		
1.5kg	27	20.5
2kg	67	50.8
2..5kg	32	24.2
3kg	3	2.3
Others	3	2.3
Total	132	100
Average age of broodstock		
6-7 months	15	11.4
8-9 months	30	22.7
10-11 months	55	41.7
12 months +	32	24.2
Total	132	100
Dominant fish species		
<i>Clarias spp (catfish)</i>	115	87.1
<i>Oreochromis spp (Tilapia)</i>	14	10.6
Carp	2	1.5
<i>Heterotis spp</i>	1	0.8
Total	132	100

The reliance on sex organs as the primary identification method aligns with established hatchery practices, where secondary sexual characteristics such as genital papilla structure and abdominal swelling are used to distinguish mature males and females (Eyo *et al.*, 2021; Audu *et al.*, 2023). The supplementary use of appearance and body shape further reflects practical field-based assessment of broodstock fitness (Eyo *et al.*, 2021). However, the complete absence of formal identification tools suggests limited application of standardized or genetic-based selection methods. This trend supports earlier observations that many hatchery operators in Nigeria utilize broodstock of uncertain genetic origin, which may contribute to inbreeding and inconsistent seed quality (Srikulnath *et al.*, 2025; Kwikiriza *et al.*, 2025; Ola-Oladimeji, 2021).

In terms of broodstock sourcing, more than half of the respondents (54.5%) obtained broodstock from fish farms, followed by grow-out ponds (26.5%) and the wild (15.2%), while a small proportion (3.8%) acquired broodstock as gifts. This pattern reflects a mixed sourcing system, combining farmed and wild genetic material. Similar practices have been reported in Nigeria and other African aquaculture systems, where farmers depend on multiple sources based on availability and cost considerations (Eyo *et al.*, 2021; Srikulnath *et al.*, 2025; Kwikiriza *et al.*, 2025). While integrating broodstock from different sources can potentially enhance genetic diversity and reproductive performance when properly managed (Eyo *et al.*, 2021; Yekaws *et al.*, 2021), the absence of controlled breeding programmes and genetic characterization increases the risk of genetic drift, inbreeding, and variable hatchery outputs (Srikulnath *et al.*, 2025; Kwikiriza *et al.*, 2025; Ola-Oladimeji, 2021).

The results further indicate that the most commonly used broodstock weight was 2 kg (50.8%), followed by 2.5 kg (24.2%) and 1.5 kg (20.5%), with very few respondents using broodstock weighing 3 kg or above (2.3%). Similarly, the majority of broodstock were aged between 10-11 months (41.7%), while 24.2% were 12 months and above, and smaller proportions were 8-9 months (22.7%) and 6-7 months (11.4%). This distribution suggests that hatchery operators predominantly utilize medium-sized and relatively young broodstock.

Experimental evidence indicates that larger and older broodstock generally exhibit higher fecundity, improved fertilization rates, better hatchability, and enhanced fry survival compared to younger fish (Saidu *et al.*, 2025; Jokthan, 2013). Therefore, the use of broodstock below optimal age thresholds, particularly those under 10-11 months, may limit reproductive efficiency and seed quality. While the common use of broodstock within the 2-2.5 kg weight range is generally favorable for reproduction, the relatively lower proportion of older broodstock suggests that some hatchery operators may not be fully optimizing broodstock performance.

With respect to species composition, the overwhelming majority of respondents (87.1%) cultured *Clarias* species (catfish), while *Oreochromis* species (tilapia) accounted for 10.6%, and carp (1.5%) and *Heterotis* (0.8%) were minimally represented. This dominance of *Clarias* species reflects their established importance in Nigerian aquaculture, where they are widely preferred due to their fast growth rate, hardiness, and suitability for induced breeding (Robert *et al.*, 2024). The limited presence of other species suggests a high level of specialization among hatchery operators in the study area. Although there is growing interest in hybrid catfish and other clariid species for improved performance traits (Yekaws *et al.*, 2021; Srikulnath *et al.*, 2025), their low adoption in Kogi State may be attributed to technical constraints, higher production costs, or market preferences.

3.3 Artificial Propagation Techniques and Hatchery Inputs

The results in Table 3.3 show that artificial propagation among hatchery operators in Kogi State is characterized by the widespread use of practical and readily accessible techniques, particularly in milt extraction, hormone application, and hatchery inputs.

Table 3.3: Artificial Propagation Techniques and Hatchery Inputs among Catfish Hatchery Operators in Kogi State, Nigeria

Variable	Frequency	Percent
Milt extraction Method		
Manual stripping	15	11.36
Surgical extraction	2	1.52
Sacrificing the male	111	84.09
Catheterization	4	3.03
<i>Total</i>	132	100
Do you store milt?		
Yes	56	42.42
No	76	57.58
<i>Total</i>	132	100
Milt Storage Method		
Ice bath	24	31.58
Refrigerator	28	36.84
Vacuum sealed container	4	5.26
<i>Total</i>	56	100
Hormone Used		
Ovulin	45	34.09
Ovaprim	28	21.21
Fresh fish pituitary	9	6.82
Ovatide	50	37.88
<i>Total</i>	132	100
Source of Saline Water		
Medicine stores	46	34.85
Alcohol solution	42	31.82
Farm made	44	33.33
<i>Total</i>	132	100
Starter Feed Used		
Artemia	28	21.2
Gemma wean	71	53.8
Mem prime	33	25
<i>Total</i>	132	100
Fish Seed Size Produced		
Fry	9	6.8
Fingerlings	23	17.4

Post fingerlings	35	26.5
Juveniles	65	49.2
Total	132	100

A dominant proportion of respondents (84.09%) reported obtaining milt by sacrificing the male fish, while considerably fewer relied on manual stripping (11.36%), catheterization (3.03%), or surgical extraction (1.52%). This strong preference for sacrificing males reflects a common practice in catfish hatcheries, where post-mortem extraction provides high volumes of milt with minimal technical requirements (Tine, 2021; Mbaye *et al.*, 2022). While this approach simplifies the breeding process and ensures adequate sperm supply, it limits the reuse of male broodstock and may increase production costs over time. Alternative methods such as stripping and catheterization, although less commonly used, require higher technical expertise and careful handling to maintain fertilization efficiency (Kucska *et al.*, 2022).

Milt storage practices were also limited among respondents, with 57.58% indicating that they do not store milt, compared to 42.42% who practiced some form of storage. Among those who stored milt, refrigeration and ice bath methods were the most commonly used. This pattern reflects the operational scale of many hatcheries, where short-term storage methods are preferred due to their simplicity and low cost. Studies have shown that properly handled chilled storage can preserve milt quality for short durations, suggesting that improved storage practices could enhance fertilization outcomes and reduce the need for frequent broodstock sacrifice (Akinagbe *et al.*, 2025; O *et al.*, 2025).

Hormone usage among hatchery operators was dominated by synthetic products, with Ovotide (37.88%), Ovulin (34.09%), and Ovaprim (21.21%) being widely used, while fresh fish pituitary was minimally utilized (6.82%). This distribution reflects a broader shift towards commercial hormones, which are easier to administer and provide more predictable spawning outcomes compared to traditional pituitary extracts (Tine, 2021; Andriani *et al.*, 2023). Although studies have demonstrated that pituitary extracts can achieve comparable or even superior results under controlled conditions, synthetic hormones remain more popular due to their convenience and consistency (Abubakar and Miftahu, 2024). The sourcing of saline water from medicine stores (34.85%), farm-made solutions (33.33%), and alcohol-based preparations (31.82%) further highlights the adaptive strategies employed by hatchery operators to manage input costs and availability. The use of saline as a diluent for hormones and milt is widely reported and has been shown to support effective fertilization when properly applied (Assan *et al.*, 2020).

The choice of starter feeds also reflects a combination of commercial and practical considerations. More than half of the respondents (53.8%) used Gemma wean, while others used Mem prime (25%) and Artemia (21.2%). The use of high-quality commercial feeds alongside live feed such as Artemia is consistent with established hatchery practices, where early larval nutrition plays a critical role in determining survival and growth performance (Tine, 2021; Mbaye *et al.*, 2022). Inadequate or inappropriate feeding at the larval stage has been associated with high mortality rates, emphasizing the importance of selecting suitable starter diets.

In terms of production output, the majority of hatchery operators produced juveniles (49.2%), followed by post-fingerlings (26.5%), fingerlings (17.4%), and fry (6.8%). This indicates a

preference for producing larger and more robust seed sizes, which are generally associated with higher survival rates and better performance under grow-out conditions. Similar trends have been observed in intensive hatchery systems, where the production of advanced fingerlings and juveniles is prioritized to reduce mortality risks and improve farmer outcomes (Andriani *et al.*, 2023; Arif and Farikhah, 2025).

3.4 Water Quality Management and Health Control Practices

The results in Table 3.4 indicate that hatchery operators in Kogi State rely largely on natural and readily available water sources, with rivers (44.7%) being the most commonly used, followed closely by boreholes (40.9%), while wells accounted for a smaller proportion (14.4%). The reliance on river water reflects its accessibility and low cost; however, this source is often associated with fluctuating water quality and a higher risk of contamination. Studies have shown that surface waters in aquaculture systems may harbor high microbial loads, including pathogenic organisms, which can increase the risk of disease outbreaks in fish populations (Atawodi *et al.*, 2025; Wanja *et al.*, 2020; Nur *et al.*, 2020).

Table 3.4: Water Quality Management and Health Control Practices among Catfish Hatchery Operators in Kogi State, Nigeria

Variable	Frequency	Percent
Sources of water		
Bore hole	54	40.9
River	59	44.7
Well	19	14.4
Total	132	100
Water quality maintenance		
Aeration	85	64.4
Filtration	23	17.4
Others	24	18.2
Total	132	100
Water quality monitoring		
Everyday	71	53.8
Every three days	45	34.1
Every week	15	11.4
Others	1	0.8
Total	132	100
Most common disease		
Bacteria	53	40.15
Fungal	26	19.69
Virus	19	14.39
Bacterio-fungal	32	24.24
Others	2	1.53
Total	130	100
Lab for water quality on site		

Yes	53	39.7
No	69	60.3
Total	132	100
On site lab for disease diagnosis		
Yes	45	34.4
No	86	65.7
Total	132	100
Health Management Practices		
Vaccination	36	27.7
Medication	77	58.33
Others	19	14.4
Total	132	100

To manage water quality, the majority of respondents (64.4%) relied on aeration, while fewer used filtration (17.4%) or other methods (18.2%). The prominence of aeration highlights its importance in maintaining adequate dissolved oxygen levels, which is critical for fish metabolism, growth, and resistance to stress and disease. Experimental studies have demonstrated that continuous aeration can significantly improve growth performance and enhance resistance to bacterial infections such as *Aeromonas* in African catfish (Abarike *et al.*, 2024). However, the relatively low adoption of filtration suggests that suspended solids, organic waste, and microbial contaminants may not be effectively removed, particularly in systems supplied by surface water sources (Nur *et al.*, 2020).

Water quality monitoring practices varied among respondents, with just over half (53.8%) conducting daily monitoring, while others monitored every three days (34.1%) or weekly (11.4%). Although frequent monitoring is essential for maintaining optimal hatchery conditions, studies indicate that without systematic measurement of key parameters such as ammonia, nitrite, pH, and temperature, and proper record-keeping, it becomes difficult for farmers to effectively link water quality fluctuations to fish health outcomes (Opiyo *et al.*, 2018; Nayan *et al.*, 2021). This suggests that while monitoring is practiced, its effectiveness may be limited by the level of technical detail involved.

The disease profile reported by respondents was dominated by bacterial infections (40.15%), followed by combined bacterial and fungal infections (24.24%), fungal infections alone (19.69%), and viral infections (14.39%). This distribution is consistent with findings from other aquaculture systems, where bacterial pathogens are the primary cause of mortality in catfish hatcheries, often exacerbated by poor water quality, high stocking densities, and environmental stress (Opiyo *et al.*, 2018). The presence of mixed infections further suggests suboptimal environmental conditions that favor opportunistic pathogens.

The availability of diagnostic infrastructure was limited, as the majority of respondents reported not having on-site laboratories for water quality analysis (60.3%) or disease diagnosis (65.7%). This lack of diagnostic capacity is consistent with reports from other developing aquaculture systems, where limited access to laboratory facilities and technical expertise constrains accurate disease identification and management (Opiyo *et al.*, 2018; Wanja *et al.*, 2020; Faruk and Anka,

2017). As a result, many hatchery operators may rely on generalized or empirical treatment approaches rather than targeted interventions.

Health management practices further reflect this trend, with medication being the most commonly used approach (58.33%), followed by vaccination (27.7%) and other methods (14.4%). The dominance of medication suggests a reactive approach to disease management, where treatment is prioritized after disease occurrence rather than prevention. Similar patterns have been reported in both African and global aquaculture systems, where the widespread use of chemotherapeutics raises concerns about cost, effectiveness, and the potential development of antimicrobial resistance (Opiyo *et al.*, 2018; Benedicenti *et al.*, 2024; Mukaila *et al.*, 2023). In contrast, studies emphasize that preventive strategies, including improved water quality management, biosecurity measures, and regular health monitoring, are more sustainable and effective in reducing disease incidence (Wanja *et al.*, 2020).

4.0 Conclusion

This study examined the breeding practices, broodstock management, artificial propagation techniques, and health management strategies among catfish hatchery operators in Kogi State, Nigeria. The findings reveal that hatchery operations in the study area are moderately developed, with operators demonstrating a fair level of technical capacity and widespread adoption of artificial propagation methods. The dominance of crossbreeding, hybridization, and hormone-induced spawning indicates a strong focus on improving productivity and meeting market demand. Similarly, the preference for tank- and concrete-based hatchery systems reflects a shift toward more controlled production environments.

Despite these strengths, several limitations were identified that may affect the long-term sustainability and productivity of hatchery operations. Broodstock management practices are largely informal, with reliance on observable traits for identification and mixed sourcing from farms, ponds, and the wild, often without genetic characterization. The use of relatively young broodstock and the absence of structured breeding programmes may limit reproductive efficiency and contribute to genetic deterioration. In addition, while artificial propagation techniques are widely practiced, methods such as routine sacrifice of male broodstock and limited milt storage indicate inefficiencies that could increase production costs over time.

Water quality and health management practices also present notable challenges. Although aeration and regular monitoring are commonly practiced, the limited use of filtration systems and lack of comprehensive water quality assessment may expose hatcheries to environmental stress and disease risks. The predominance of bacterial and fungal infections, coupled with limited access to diagnostic facilities, has led to a heavy reliance on medication-based treatments rather than preventive health management approaches. This reactive strategy may have implications for fish survival, production costs, and long-term system sustainability.

5.0 Recommendations

- i. The study recommends that efforts be directed toward strengthening technical capacity through targeted training and extension services, particularly in areas such as genetic management, broodstock selection, and modern hatchery practices. The establishment of broodstock management programmes and the promotion of standardized identification and record-keeping systems would help improve seed quality and reduce the risks associated with inbreeding. Hatchery operators should also be encouraged to

- adopt improved milt handling and storage techniques, as well as optimize hormone usage to enhance efficiency and reduce wastage.
- ii. Furthermore, investment in water quality management infrastructure, including filtration systems and basic diagnostic facilities, is essential for improving hatchery performance. Promoting preventive health management strategies, such as biosecurity measures, routine water quality assessment, and proper hygiene practices, would reduce dependence on medication and enhance fish survival.
 - iii. Finally, policies and interventions that support access to quality inputs, technical knowledge, and research-based innovations will be critical in advancing sustainable aquaculture development in Kogi State and Nigeria at large.

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