FISH SEED PRODUCTION PRACTICES IN OVIA NORTH-EAST AND OVIA SOUTH-WEST LOCAL GOVERNMENT AREAS OF EDO STATE

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A PROJECT SUBMITTED TO THE DEPARTMENT OF AQUACULTURE AND FISHERIES MANAGEMENT, FACULTY OF AGRICULTURE, UNIVERSITY OF BENIN, BENIN-CITY IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF BACHELOR OF AGRICULTURE (OPTION IN AQUACULTURE AND FISHERIES MANAGEMENT)

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CERTIFICATION

This is to certify that this project titled **“Fish seed production practices in Ovia North-East and Ovia South-West local government areas of Edo State”** was carried out by **Ebenezer Victor, AYENI** with matriculation number **AGR1900257** of the department of Aquaculture and Fisheries Management, Faculty of Agriculture, University of Benin, Benin City, Edo State, Nigeria.

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DEDICATION

This report is dedicated to God Almighty for his gracious mercies over my life, and to my parents Mr. Victor Ayeni, and Mrs. Caroline Ayeni for their love, guidance, and staunch support towards my academic pursuit.

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TABLE OF CONTENTS

Title page - - - - - - - - - - i

Cover page - - - - - - - - - - ii

Certification - - - - - - - - - - iii

Dedication - - - - - - - - - - iv

Acknowledgements - - - - - - - - - v

Table of Contents - - - - - - - - - vi

List of Tables - - - - - - - - - - x

List of Figures - - - - - - - - - - xi

Abstract - - - - - - - - - - xii

CHAPTER ONE

1.0 INTRODUCTION - - - - - - - - 1

1.1 Justification of the study - - - - - - - - 2

1.2 Aim and Objectives of the study - - - - - - - 4

CHAPTER TWO

2.0 LITERATURE REVIEW - - - - - - - 5

2.1 Overview of aquaculture production in Nigeria - - - - - 5

2.1.1 Fish seed production in Nigeria - - - - - - 7

2.2 Fish seed production systems - - - - - - - 10

2.2.1 Collection of fish seed from the wild - - - - - - 10

2.2.2 Natural spawning in ponds and tanks - - - - - - 11

2.2.3 Hormonal-induced spawning - - - - - - - 13

2.2.4 Artificial fertilization - - - - - - - - 15

2.3 Fish seed production in hatcheries - - - - - - 16

2.3.1 Operations in a fish hatchery - - - - - - - 17

2.3.1.1 Broodstock selection and management - - - - - 17

2.3.1.2 Spawning by artificial inducement - - - - - - 18

2.3.1.3 Nursing of hatchlings - - - - - - - - 19

2.3.1.4 Water quality management - - - - - - - 20

CHAPTER THREE

3.0 MATERIALS AND METHODS - - - - - - 21

3.1 Description of Study Area - - - - - - - 21

3.2 Sampling Procedure and Sampling Size - - - - - - 22

3.3 Data Collection - - - - - - - - - 22

3.4 Sampling Size - - - - - - - - - 24

3.5 Data Analysis - - - - - - - - - 24

CHAPTER FOUR

4.0 RESULTS - - - - - - - - - 25

4.1 Demographic characteristics of respondents - - - - - 25

4.2 Socioeconomic characteristics of respondents - - - - - 26

4.3 Hatchery management practices - - - - - - - 28

4.4 Broodstock management practices - - - - - - 30

4.5 Production output from hatchery - - - - - - - 31

4.6 Constraints faced in hatcheries - - - - - - - 33

CHAPTER FIVE

5.0 DISCUSSION - - - - - - - - - 34

5.1 Demographic characteristics of respondents - - - - - 34

5.1.1 Gender distribution - - - - - - - - 34

5.1.2 Age distribution of hatchery operators - - - - - - 35

5.1.3 Marital status of respondents - - - - - - - 36

5.1.4 Educational level of respondents - - - - - - 36

5.2 Socioeconomic characteristics of respondents - - - - - 37

5.2.1 Religious affiliation of respondents - - - - - - 37

5.2.2 Household size of respondents - - - - - - - 38

5.2.3 Primary occupation of respondents - - - - - - 38

5.2.4 Membership in cooperative societies - - - - - - 39

5.2.5 Sources of business capital - - - - - - - 40

5.2.6 Breeding experience of respondents - - - - - - 40

5.2.7 Hatchery ownership - - - - - - - - 41

5.3 Hatchery management practices - - - - - - - 41

5.3.1 Water quality management - - - - - - - 41

5.3.2 Temperature regulation methods - - - - - - 42

5.3.3 Feeding techniques - - - - - - - - 43

5.3.4 Predation control measures - - - - - - - 44

5.3.5 Disease prevention strategies - - - - - - - 44

5.3.6 Fish transfer methods - - - - - - - - 45

5.4 Broodstock management practices - - - - - - 45

5.4.1 Broodstock selection methods - - - - - - - 45

5.4.2 Broodstock reuse - - - - - - - - 46

5.4.3 Recovery period before reuse - - - - - - - 46

5.4.4 Male-to-Female ratio - - - - - - - - 47

5.4.5 Male usage after spawning - - - - - - - 47

5.5 Production output from hatcheries - - - - - - 48

5.6 Constraints faced in hatcheries - - - - - - - 49

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS - - - - 51

6.1 Conclusion - - - - - - - - - 51

6.2 Recommendations - - - - - - - - 52

REFERENCES - - - - - - - - - 53

APPENDIX I - - - - - - - - - - 59

LIST OF TABLES

Table 4.1: Demographic characteristics of respondents - - - - 25

Table 4.2: Socioeconomic characteristics of respondents - - - - 27

Table 4.3: Information on hatchery management - - - - - 29

Table 4.4: Broodstock-related management practices - - - - 30

Table 4.5: Information on production output from hatcheries - - - 32

LIST OF FIGURES

Fig. 3.1: Map of Edo State showing the study area - - - - - 23

Fig. 4.1: A bar chart illustrating the percentages of respondents affected by each constraint in hatchery operations - - - - - - - - - 33

ABSTRACT

Fish seed production is a fundamental aspect of aquaculture, ensuring the continuous supply of high-quality fish seeds for commercial and subsistence fish farming. This study examined the fish seed production practices in Ovia North-East and Ovia South-West local government areas of Edo State, Nigeria. The objectives were to assess the socio-economic characteristics of fish seed producers, evaluate their management practices, analyze production output, and identify constraints affecting fish production in the study area. The non-probability chain referral sampling procedure was employed, with data collected from 100 fish hatchery operators using structured questionnaires. The collected data were analyzed using S.P.S.S Version 15.0, and presented using descriptive statistics, including tables, charts, and percentages.

The findings revealed that fish seed production is largely undertaken by middle-aged (51.9%), experienced (40.5%), and predominantly male operators (94.9%). Also, *Clarias gariepinus* and *Heterobranchus bidorsalis* (97.5%) were predominant species bred in hatcheries. Water quality management was a key concern, as many operators relied on basic flow-through systems (73.2%) and oxygenation methods (25.6%) to maintain optimal conditions. Broodstock reuse was common, with most operators (89.7%) allowing a recovery period of 3 – 4 months before reuse. The study identified poor water quality leading to fry mortality (55.7%), financial constraints (27.9%), feed availability and cost (13.9%), and theft (2.5%) as the major challenges faced by hatchery operators.

Based on the findings, the study recommends enhanced training programs, targeted funding schemes, better water quality management strategies, and security measures to enhance efficiency and overall productivity of fish seeds in the study area. Also, further studies should be carried out on other aspects of the fish seed production value chain to enable a comprehensive understanding of the fish seed production in the study area.

CHAPTER ONE

1.0 INTRODUCTION

The rapid increase in Nigeria and the world population in general, has led to high competition for natural resources, especially food resources. To attain global food security, the fisheries and aquaculture sector has been identified an important sector (FAO, 2020). Aquaculture, one of the sub sectors of the Nigeria fishery industry started over 50 years ago (Olagunju *et al.*, 2007). The aquaculture industry in Nigeria stands as a pivotal contributor to the nation's economy, addressing the increasing demand for protein and offering significant economic opportunities for millions. It holds immense significance, particularly in the face of increasing pressure on wild fish stocks and the need to meet the burgeoning demand for fish protein.

The fundamental prerequisite for successful aquaculture include producing fish seeds for stocking. In recent past, fish fingerlings were sourced from the wild i.e.: natural waters. Although, fish seeds could be collected from the wild, the system is seasonal, unreliable, laborious, and above all, the viability of such seeds cannot be assured (Olanrewaju *et al*., 2010). Artificial propagation of fish (spawning) is the most promising and reliable way of ensuring availability of good quality fish seeds all year round, and the sustainability of the aquaculture industry at large. To this end, aquaculture or fish culture heavily relies on artificial propagation techniques to obtain fish seeds of desired fish species for cultivation.

Fish seed is the most important component of fish culture, and for this to be available in abundance, there is need for best practice, compliant, sustainable fish hatcheries (Nasir *et al*., 2014). Fish hatcheries are facilities dedicated to the artificial propagation of fish seeds. In these facilities, parent stocks are well-managed, fish eggs are carefully collected as well as milt, fertilized, and incubated in controlled environments to ensure successful hatchings. Once the fish eggs hatch, the larvae are closely monitored and cared for to ensure optimal growth and development.

Recognizing the vulnerability of young fish, fish hatcheries aims to enable a nurturing environment that maximizes the survival and vitality of young fish during their critical early stages of development. To do this, fish hatcheries employ diverse strategies and operations such as controlling water temperature, providing adequate nutrition, minimizing stressors, and carefully monitoring water quality. Additionally, they may use specialized equipments and technologies to mimic natural conditions and optimize growth rates. In essence, fish hatcheries are indispensable for the artificial propagation of fish seeds, and it is crucial to emphasize the importance of optimizing fish hatchery operations to ensure efficient and effective production of fish seeds.

1.1 Justification of the study

It has been noted that fish farming is hardly imaginable without availability of fish seed (Chondar, 1980). The demand for fish seeds is more than the supply, as a result of increase in fish farming to cushion malnutrition and higher price of alternative protein sources. Hence, the need to increase fish fingerlings production and management of fish hatchery to bring about self-sufficiency in aquaculture (Olaoye *et al.,* 2011). In spite of the remarkable success on the hatching of some fish species, the survival at fry stage is still a limiting factor. This can be attributed to lack of proper awareness of the technicality involved in the principles of fish hatchery operations and production practices. Okonji and Ojeikere (2020) noted that one of the sensitive areas of hatchery operations is water quality management which significantly influences the success of fish seed production. Thus, for fish seed production to be successful and sustained, perfect knowledge and understanding of the hatchery operations are key and fundamental.

Ovia River is located in Ovia North-East and Ovia South-West region of Edo State in Nigeria. The river flows in a south-west direction. The river, whose source is the Akpata hills in Ekiti State flows through several towns and villages which include Iguoriakhi, Ikoro, Ekenwan, Gelegele. It is among the most widely used water bodies in Edo State for domestic, industrial, commercial and recreational purposes. This has attracted fish farmers in the locality, and has led to establishments of pockets of fish hatcheries, whose operations needs to be evaluated viz-a-viz the potential such operations hold for the industry. Similar studies have been done by Olaoye *et al*. (2011), while studying the factors determining fish hatchery operations in Ogun State, and reported that high cost of investment and feeding, poor genetic broodstocks, high level of quackery were problems facing the development of aquaculture in the area. A more recent study was done by Badaru *et al*. (2022) on the recent advances in fish hatchery operations around Sokoto metropolis and found out that the major problems affecting the spawning operations in commercial fish farms is environmental challenges such as water quality, availability and temperature fluctuations.

There is paucity of knowledge and comprehensive data on fish seed production practices and hatchery operations in Ovia North-East and Ovia South-West local government areas of Edo State. Thus, there is need for a study that will fill this crucial knowledge gap by providing detailed insights into the status, challenges, and opportunities of fish seed production in Ovia North-East and Ovia South-West local government areas of Edo State. This study therefore looks at the fish seed production practices in Ovia North-East and Ovia South-West local government areas of Edo State.

1.2 Aim and Objectives of the study

This study examines fish seed production practices in Ovia North-East and Ovia South-West local government areas of Edo State.

The specific objectives of the study are to:

1. describe the socio-economic characteristics of fish breeders in the study area.
2. evaluate the management practices of fish breeders in the study area.
3. obtain data about the production output from fish hatcheries within the study area.
4. identify the constraints associated with fish seed production in the study area.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview of aquaculture production in Nigeria

Aquaculture to which fish farming is categorized is the commercial rearing of fish in settings where the basic means of production can be managed within their respective limit and where producers strive for optimal economic results. It is the cultivation of aquatic organisms that could (freshwater and saltwater populations); aquatic organisms that could be reared include fish, insects, bivalves and pearls, mollusk, crustaceans, and aquatic plants, while the controlled environments include ponds, cages, pens, and raceways (Tunde *et al*., 2015). Most of these aquatic organisms are consumed by man to meet their demand for high quality animal protein. However, at present species such as tilapia, carp, mudfish, and catfish are the only cultured fishery operation in Nigeria.

Aquaculture is growing swiftly throughout the world and it has the prospective for the provision of valuable protein for human consumption. In Nigeria economy, as in most African countries, aquaculture plays a significant role in employment creation and income generation (Mulokozi *et al*., 2020). This is mostly true of the socio-economically weaker communities of fishermen who depend on the sale of their yields for livelihood. Despite the importance of aquaculture being the fastest growing food producing sector, its contribution to Nigeria's total fish production is of little importance. In 2010 for instance, the projected population in millions, fish demanded in million ton, and fish supplied in million tons were 151.21, 1.15 and 0.93 respectively; in 2011, the statistics rose to 155.50, 1.18 and 0.96; in 2012, the statistics rose to 159.90, 1.22 and 1.00; the statistics rose to 164.40, 1.25 and 1.04 in 2013; in 2014, the statistics rose to 169.10, 1.29 and

1.08; in the year 2015, the population was projected at 173.90 million, fish demanded was 1.32 million tons and the estimated fish supplied was 1.15 million tons; in 2016, the statistics rose to 178.80, 1.36 and 1.16 respectively; the projected statistics respectively rose to 183.30, 1.39 and 1.20 in 2017 (Amosu *et al.*, 2017).

The current fish demand consumption in Nigeria stands at 1.4 million metric tons (Onyekuru *et al*., 2019), to satisfy the dietary requirements of its citizens but the total aggregate domestic fish supply from all sources (capture and culture fisheries) is less than 0.7 million metric tons per annum. Nigeria has to import about 0.7 metric tons of fish valued at about $500 million annually to augment the shortfall. It is estimated that Nigeria spends over 288 billion naira on annual fish importation (CBN, 2017). Increasing the aquaculture production is clearly needed to meet this demand, but despite this, demand for fish consumption exceeded the supply thereby making Nigeria one of the major importers of fish. The massive importation of frozen fish in the country has ranked Nigeria the largest importer of frozen fish in Africa (FMARD, 2012). Federal Ministry of Agriculture and Rural Development (2012) asserted that among the four major fish supplies sources in Nigeria, aquaculture still remained the poorest contributor. Supplies from importation, inland and coastal artisanal fishery, and industrial trawl fishery surpass that from aquaculture.

There are many constraints militating against the development of aquaculture to meet the global food security and economic growth and in Nigeria especially. FMARD (2016), opined that the major value chain constraints in aquaculture are low productivity of fish breeds in aquaculture and low production due to lack of inputs. Oluwatayo and Adedeji (2018), stated that fish farming as an industry is generally faced with some challenges which includes the insufficient production of cultivable fish species fingerlings, and poor availability of cost-effective feed for fish culture among others.

2.1.1 Fish seed production in Nigeria

Although domestication of species and advances in induced breeding have enhanced the breeding of fish in captivity and extend the spawning season to a limited degree, it has not yet allowed substantial seed production outside the normal spawning season for many species (George *et al*., 2010). At present, a large percentage of the total seed requirements for aquaculture are obtained from the wild, where supply is completely dictated by the natural breeding cycle of the target species. Fish seed obtained from the wild is found to be unreliable, because it is seasonal and usually mixed species, some which do not meet the criteria of good aquaculture candidates. Other factors which can cause unpredictability of seed supply include flooding and other man-made disasters, including spills, disease outbreaks, and limited availability of feeds for broodstock and larvae (Mair, 2002).

Main sources of fingerlings in Africa are wild catches, unregulated spawning in ponds, and government hatcheries. In Egypt, Uganda and Nigeria, which are the leading aquaculture producers on the continent, the private sector is by far the largest producer of fish and fingerlings (Brummett 2007; FAO 2010; Aulanier *et al*., 2010). Hatchery production based on controlled spawning is popular among commercial hatcheries. However, most of the hatcheries are either totally abandoned or under-producing because of a lack of technical capabilities among the managers (Brummett, 2007). All studies on fish seed production reported that demand for fish seed outstrips supply in most African countries (Shikuku *et al*., 2021). Three studies (Brummett 2007; George *et al*., 2010; Adewumi 2015) reported that the deficit in supplemented through imports.

The African catfish, *Clarias gariepinus*, is the commercial aquaculture species in Nigeria. A major problem identified as hindering the promotion and development of the aquaculture industry in Nigeria has been scarcity of fish fingerlings. Inadequate fish seed supply is a major constraint to aquaculture development in Nigeria (Otubusin, 1988). Desired quantity and quality has never been available. While in present total production and supply from all sources is less than 50 million fingerlings, the requirement in the short term is at least 500 million, annually (George *et al*., 2010). Until about 15 years ago, no less than 60% of the all fish seed supply in Nigeria was from the wild (Bondad-Reantaso, 2007). Many fish farms have been abandoned in the country for the lack of fish seed. The lack of technical knowhow is a major impediment to fish seed production in countries such as Nigeria (Shikuku *et al*., 2021). Many technical problems arise in the production of seed either in the pond or hatchery system. Principal among these are: lack of and poor management of broodstock, especially feeding and handling; and the poor record keeping of all activities regarding induced spawning, care of eggs, fry, feeding, and general management of fingerlings (Atanda, 2006).

Lack of fish fingerlings has been one of the major constraints for aquaculture development in Nigeria for the past 40 years (Aquaculture and Inland Fisheries Project (AIFP), 2005). Fish seeds are indispensable to the operations of fish farms. Thus, the federal government of Nigeria introduced the fish farm project under which pilot fish farms were established for potential fish farmers to replicate so as to produce more fish for people. In addition, the Fish Seed Multiplication Project was designed to provide fish farmers with fingerlings with which to stock their ponds (Federal Department of Fisheries (FDF), 1995). The earliest of such training programmes by the Federal Department of Fisheries was assisted by FAO between 1978 and 1981, when two fish seed multiplication and fish farming demonstration centres were established at Panyam fish farm in Plateau state (North Central Nigeria), and Oyo fish farm (South-West). Regular on-farm, hands-on training was organized for the prospective fish farmers and fish seed producers at these centres. Two additional centres were later established at Umina-Okigwe (South-Eastern Nigeria) and Mando Road, Kaduna (North-Western Nigeria). However, these projects have, to date, been largely ineffective and could not supply adequate quantities of fish seed for neither the government projects, nor the private individuals (Barker, 1986).

During the last decade, almost all hatchery infrastructure and table fish production systems have been exclusively targeted towards catfish production because of its hardiness and ease of culture. This has led to the emergence of large number of fish farms under small-, medium-, and large-scaled production systems. This has been accompanied with increasing demand for fish fry and fingerlings. However, output from government- and private-owned hatcheries has not been adequate to meet the demand for fish seed in Nigeria. The development of hatchery production, among other aspects of aquaculture, can only be enhanced by introduction of improved technologies. Dissemination of proven technologies entails sharing and distribution of information to target audience to bridge knowledge gap and bring change in attitude as well as improving skill of the end users (Oghenetejiri and Ademuyiwa, 2017). Due to the wide gap between demand and supply of fingerlings and table size fish, a package tagged 'improving breeding and hatchery management practices' was designed and disseminated to farmers in Lagos state. The package comprised of introduction of improved broodstocks, which was to increase the quality and quantity of fish seed, introduction of hormonal treatment to broodstock to improve fecundity rates. Management practices such as early sorting of fry, use of hatching troughs, siphoning of hatchlings, use of graders were introduced to improve survival rates of fry and fingerlings (Ofuoku *et al*., 2008). Flow through systems and the use of air stones were also among the technology in the disseminated package which was to improve the water quality. According to Ike and Onuegbu (2007), the package was publicized to improve the quality and quantity of fish seed which will directly increase fish production in Lagos state. Despite the dissemination of this package, the fish seed production of the state is still low and inadequate to meet the increasing fish farms' demand for fry and fingerlings (Oghenetejiri and Ademuyiwa, 2017).

2.2 Fish seed production systems

Fish farming begins with the stocking of fry (fish seeds), and these can come from the wild or be produced in the farm. Whatever their origin, they are indispensable and the means of obtaining them influences directly farm production. If supplies are erratic, there will be interruption of other farm activities; if the supplies are regular, farm production will be maximized (Delince *et al*., 1987). It has been noted by Atanda (2006) that the systems of fish seed production in Nigeria include: collection from the wild; natural breeding in ponds; spawning in tanks; induced natural spawning in ponds and tanks; artificial fertilization (hatchery production and management); and through genetic manipulation. Effective fish seed production systems ensure a consistent supply of high-quality fish seeds, enabling farmers to produce healthy and disease-free fish.

2.2.1 Collection of fish seed from the wild

The earliest method of obtaining fish stocking material was collecting fry from the wild. This approach is still used today for certain species whose spawning behavior has not been successfully replicated in captivity, or when artificial propagation is too costly or impractical (Delince *et al*., 1987). Rivers, natural lakes, lagoons, estuaries, creeks, swamps, pools and seas are traditional sources of young fish. Other wild sources of fish seeds are depressed lands that are usually flooded especially during raining season. Canals or channels that supply water from big river or lagoons also, can be sources of young fish (Akankali *et al*., 2011). Collecting fingerlings from the wild is unreliable, as it is not possible to accurately determine quality metrics such as species and age. Availability is also seasonal.

The primary fishing gear used to collect fish fry are fixed purse net and set bag nets (Bhuiyan *et al*., 2019). Spawn collection net are made locally and are mostly similar in shape, size, and operation; they are set in shallow water against the water current, and collected spawns are kept in hapa until they are sold (Tsai *et* al., 1981). Fertilized eggs are collected using a seine net mostly made of mosquito nylon netting (9 to 12m long and 3 to 4m wide) operated from a boat by two fishermen (Tsai *et al*., 1981). Collected fertilized eggs are sold to hatchery owners (Bhuiyan *et al*., 2019). However, the collection and contribution of fish seed from the wild has greatly reduced over the years. The destruction of fish resources due to indiscriminate capture of brood fish, destruction of spawning ground, illegal sand quarrying, and pollution of the river by industrial and agricultural wastes have been a major concern (Alam *et al*., 2020; Kabir *et al*., 2015).

2.2.2 Natural spawning in ponds and tanks

Natural spawning is reproduction in captivity without any use of hormonal treatment. In fish ponds, natural breeding is achieved, having acquired a thorough knowledge of the reproductive biology and habits of the culture fish. The fish breeder must provide and simulate the natural environment to succeed in the spawning of species (Adekoya *et al*., 2006). Tilapia species spawn naturally in fish ponds. Natural spawning of tilapia is achieved when mature male and female tilapia is stocked together in ponds or tanks Provision of substrate or shallow pond margin enhances natural spawning of tilapia. For Clarias, natural spawning can be achieved through simulation of flooding. Increasing and decreasing the volume of water in the ponds intermittently may trigger natural spawning in *Clarias gariepinus* (Akankali, 2011). In *Ictalurus punctatus*, reproduction traits and practices have been reviewed by Busch (1985) and Tucker and Robinson (1990). In nature, channel catfish spawn under edges, around or in submerged logs, stumps or roots and in cavities in the bank. The male typically prepares a nest by clearing soft mud and debris from an easily protected area. Channel catfish are sequential spawners. Periodically, the female deposits a layer of eggs and the male fertilizes them. Clemens and Sneed (1957) reported that it takes 4 to 12 hours for a brood fish to pair to complete an egg mass with eggs being released five to ten times per hour. The male assumes care of the egg mass after oviposition.

The method of propagation most commonly practiced is the *"pond method"* in which seasonally ripe brood fish held in ponds are provided with spawning with spawning containers and allowed to spawn at will. This method, requires minimal facilities and the less amount of time, labour and skill of the culturist. Spawning success (percentage of female spawning) ranges from less than 40 to over 80%, depending on water temperatures during spawning season and condition of broodstock (Tucker and Robinson, 1990). As one male can spawn several times in one season, a sex ratio in favour of females was often used. However, Bondari (1983) obtained equal spawning success (in terms of spawns produced, egg mass weight or hatchery traits) in ponds stocked with male to female ratio 1:1, 1:2, 1:3, and 1:4. However, the average number of days required for a female to produce an egg mass was longer for fish stocked at the 1:4 ratio versus those stocked at the 1:1 ratio. A 1:1 sex ratio was recommended by Smitherman *et al*., (1983) in order to minimize inbreeding.

In *Clarias gariepinus*, successful spawning can be achieved when ripe fish are placed in freshly filled ponds that had been dry for a time (De Kimpe and Micha, 1974; Van Der Waal, 1974). However, the number of fingerlings obtained is generally very poor (Richter, 1976). As *Clarias gariepinus* does not show any parental care (Bruton, 1979), the fry are not concentrated. As parental care ends after hatching, the newly hatched larvae are susceptible to heavy predation in ponds. Cannibalism between the young fish and heavy predation by frogs, aquatic insects and other aquatic animals occur, and can be considered as responsible for the low fry survival. Because of these limitations, such breeding method has not much practical importance.

2.2.3 Hormonal-induced spawning

Richter and Van der Hulk (1982) reported that the problem of inadequate supply of fish seed can only be solved through induced breeding by the application of various inducement materials. Various types of fish have been induced to spawn, using various hormonal materials. Some of these hormonal materials (natural and synthetic) include cHGC (Eyo, 1997; 1998), HCG (Eyo, 2002); clomiphene citrate (Aguigwo, 1991); pituitary extract (Janssen, 1985; Haniffa *et al*., 2000) and Ovaprim (Manosroi *et al*., 2004; Abol-Munafi *et al*., 2006). Induced-spawning through hormonal therapies is practiced in *S. glanis* to a greater extent (Proteau and Linhart, 1993). Among siluroids, it is in the African catfish, *Clarias gariepinus*, that the greatest variety of hormonal treatments have been tested for artificially-induced breeding of female broodfish. Based on previous studies carried out in the Indian catfish *Heteropneustes fossilis* (Sundararaj and Goswami,1977) 11-deoxycorticosterone-aetate (DOCA) was first used for artificial reproduction in *Clarias gariepinus* (De Kimpe and Micha, 1974; Pham and Raugel, 1977; Hogendoorn, 1979), but Richter and Van den Hurt (1982) demonstrated that this steroid could induce oocyte maturation only and not ovulation. As stripping of eggs could be possible after treatment with DOCA, these authors came to the conclusion that ovulation was evoked mechanically. More recently, 17 hydroxyprogesterone was used successfully for inducing both oocyte maturation and ovulation, but two successive injections were required (Frichter *et al*., 1985). Haider and Rao (1994) have induced ovulation of *Clarias batractus* females after injection of 17α 20β Pg plus salmon gonadotropins (SG-G100). The nature and role of the steroid hormones implicated in the process of oocyte maturation and ovulation in the Siluroidei were discussed by Richter *et al.* (1987).

In males, the spontaneous sperm released during the breeding season is very low in the channel catfish (Guest *et al*., 1976a) and in the *S. glanis* (Hilge, 1983). Males have been injected with hormones to stimulate spermiation. This is partly due to their low GSI and low spermatogenetic production. Various hormones have been used successfully to stimulate spermiation especially hCG in *S. glanis* (Redondo-Müller *et al*., 1990). *Pangasius sutchi and C. macrocephalus* (Na-Nakorm *et al*., 1993). *Eurotropius depressirostris* (Kruger and Polling, 1984), *Ictalurus furcatus (*Dunham, 1993). Carp pituitary homogenates were used in *S. glanis* (Redondo-Müller *et al*., 1990; Linhart and Billard, 1994). In *C. gariepinus*, Van der Waal (1985) stated that contrarily to untreated fish, it was possible to collect semen by stripping from males injected with Clarias pituitary homonogenates. GnRH was injected alone or in combination with Domperidone (Ovaprim) in *S. glanis* with limited success (Redondo *et al*., 1990). GnRH implants had also limited effect (Linhart and Billard, 1994). Tambasen-Cheong *et al*. (1995) found significant increase in semen volume and decrease in sperm density 24 hours after treatment with Ovaprim in *C. macrocephalus*. The steroids directly involved in spermiation are not precisely known. Hormonal injection usually results in a sequence of steroid secretion; in *C. batrachus* hCG induces first a peak of secretion in the blood of testosterone (and 11KT) followed by progestins and again 11KT (Zairin *et al*., 1993). In *C. gariepinus* exhibiting spontaneous spermiation the production of testosterone glucuronide was considerably enhanced (Resink *et al*., 1987a) and 5β reduced steroids were found in spawning fish but not in non-spawning individuals (Schoonen *et al*., 1987).

2.2.4 Artificial fertilization

Artificial fertilization has been practiced mostly in silurids and clariids. An improved procedure of gamete collection and fertilization was established in *S. glanis* (Linhart *et al*., 1987). The sperm is first collected either by stripping into an immobilizing solution with a dilution ratio superior to 0.9:1, or directly from testes of sacrificed or operated males. After stripping female, eggs (200ml) and sperm (3ml) are mixed together in a bowl and 100ml of activating solution (17 mM NaCl, 5mM Tris, pH 8) are added. After 2-5 minutes of gentle stirring, the eggs are transferred to incubators. Horvath and Tamas (1976) formerly used a 3 g/l NaCl solution for fertilization process. In the clariids, *C. gariepinus* and *H. longifilis*, intratesticular sperm is maintained inactivated in 155 mM NaCl solution (dilution 1:10); the time of contact between sperm and ova practiced for fertilization is generally 1 minute (Hogendoorn and Vismans, 1980; Legendre, 1986). With the view of maximizing the use of available sperm in *C. macrocephalus*, Tambasen *et al*., (1995) found an optimum ratio of 25-50 *u*l of diluted sperm (1:3:5 in NaCl 155mM) for 10g of ova and 5ml of water, corresponding to 4000-8000 spermatozoa per ovum. In *H. longifilis*, Lengendre (1992) show that the fertilization success (assessed by hatching %) dropped significantly when the number of spermatozoa used during fertilization was decreased from 50,000 to 5000 spermatozoa per ovum.

The process of sperm penetration into the egg of *S. glanis* has been investigated by scanning and transmission electron microscopy (Kudo *et al*., 1994). After activation of the egg during fertilization, the vitelline envelope undergoes considerable morphological changes resulting in the so-called fertilization envelope. The micropyle consists of a vestibule and a canal which opens in conical depression of the egg envelope. Twenty seconds after insemination, one spermatozoon has reached the sperm entry site located at the bottom of the conical depression of the egg, and the sperm head membrane fused with the egg plasma membrane. At this stage, a cytoplasmic eminence is present under the fused sperm head. After 4 min, there is a complete penetration of the sperm head and the sperm flagellum has penetrated into the egg except for a short length. During the process, sperm aggregation has been frequently observed in the upper part of the micropylar vestibule. In *S. glanis*, the internal aperture of the micropyle is wide enough to permit the entry of only one spermatozoon; this is possibly a way to prevent polyspermy (Ginsburg, 1987; Kudo, 1991).

2.3 Fish seed production in hatcheries

The process of artificial propagation of fish seeds are carried out in enclosures known as hatcheries. It involves a long range of breeding activities ranging from the collection, selection, and manipulation of breeders for spawning or stripping of eggs up to nursing hatchlings to a minimum of one month old (Akankali *et al*., 2011). Hatcheries may be owned and operated by either government or private individuals. A good fish hatchery operator seeks to produce high quality, fast growing fish seed using broodstock of known origins. Some hatcheries raise the fry until they get to juvenile stage and have commercial value; others release the fry into the wild to supplement the natural numbers of threatened or endangered species in a practice known as fish stocking. At present, aquaculture is mainly dependent on fish seed produced in hatcheries (Debnath *et al*., 2020).

2.3.1 Operations in a fish hatchery

The success of a hatchery depends on the efficient and effective management of its operations. Proper operations and management is essential to ensure the health, survival, and quality of fish seeds. Some of the operations in a fish hatchery includes broodstock selection and management, spawning via artificial inducement, nursing of hatchlings, water quality management, among others.

2.3.1.1 Broodstock selection and management

The primary requirement for fish fry production is an adequate stock of good breeders. Brood fish means the sexually matured male and female fish which are able to reproduce. Broodstock management involves manipulating environmental factors surrounding the broodstock to ensure maximum survival, enhance gonadal development and increase fecundity. The water quality parameters, feed for proper nutritive composition and particle size, resistance to diseases are some of the major factors which has to be taken into account (Bisht *et al*., 2013).

The most important thing that must be taken into consideration during management are good brood fish selection which are lively and active, free from parasites, and having well-developed gonads. Selection of broodstock can also be based on degree of maturity of eggs from the genital opening by inserting a spoon in the vent. Place the eggs in a petri dish and add a mixture of 85ml of 95% alcohol, 10ml of 40% formaldehyde and 5ml of glacial acetic acid. Fix the eggs in this solution for 2-3 minutes. The nucleus becomes opaque, while the egg yolk and cytoplasm are transparent (Nwadukwe *et al*., 1991). If the nucleus is seen in the centre of the egg, it indicates that the eggs has not yet matured, and the fish is not ready for induction. If the nucleus is eccentric, it means the egg is matured, and the fish is ready to spawn. If the nucleus is vague or cannot be seen, it means the egg is over matured or degraded, and the fish should not be induced (Akankali *et al.*, 2011).

As far as possible, broodstock should be selected from divergent sources to prevent inbreeding depression. The brood fish may be grown in the farm or captured from rivers, lakes, or reservoir and stocked in proper brood fish ponds. The brood fish ponds are built close to water supply to facilitate water management. It should be drainable and rectangular in shape with water depth of 1-2m. The selected brood fish are examined periodically for their condition and for their condition and for progress in maturity and freedom from parasites and disease infection. Proper feeding must also be taken into consideration. If the feed of the brood fish is deficient in amino acid, vitamins and minerals, the egg development is adversely affected.

2.3.1.2 Spawning by artificial inducement

Artificial breeding (induced spawning) as carried out in fish hatcheries, is simply supplementing the insufficient hormones (Richter and Van Der Hulk, 1982), which due to poor ecological conditions that would not make the fish spawn under culture condition to do so. The brood fish are captured and stripped. The eggs are collected in a dry basin. The milt is squeezed into the eggs. The mixture is then stirred gently with a feather. The eggs of some fishes are adhesive and stickiness can be removed by adding a solution of 0.4% NaCl to the eggs, immediately following mixing of eggs and milt during stripping. After this, the fertilized eggs are transferred to the incubation tank (Hogendoorn, 1981).

2.3.1.3 Nursing of hatchlings

This involves all the management work from hatching to stocking ponds. It involves a multi-faceted approach encompassing feeding and nutrition, water quality management, environmental factors, and disease management. In feeding, the behavior of the fry may be used as an indication for the quantity of feed to be administered. Hungry fry swim vigorously in the water column, whereas well-fed fry gathers in clusters on the bottom of the tank and have a considerably swollen belly. Once the fry shows satisfactory behavior, feeding can be stopped and the water supply must be resumed. Overfeeding should be avoided since wasted feed increases production cost. Temperature is an important environmental factor affecting fry development, hatch rates, and disease susceptibility. The optimal range for incubating catfish for instance, is between 26°C - 28°C. At temperature above and below this range, egg death and prevalence of diseases increases, reducing hatch rates. Each nursery tank, filled with about 160-200 litres of water may be stocked with 10,000 fry. The water supply must be adjusted according to the dissolved oxygen content of the out-flowing water. The water flow rate is regulated by the water temperature and the quantity of feed given per day. The advanced fry are transferred to nursery troughs. Transferring of advanced fry is a delicate procedure and must be done by carefully siphoning fry into a bucket. The content of this bucket is then gently released in the nursing device. After about 5-8 weeks, the advanced fry will have a weight of about 1g. At this size, they can be harvested and transferred to grow-out ponds.

2.3.1.4 Water quality management

Water quality is the totality of physical, biological, and chemical parameters, that affects the growth and survival of culture organisms. These water quality parameters include water temperature, pH, dissolved oxygen content, dissolved carbon dioxide, total ammonia-nitrogen, and total hardness (Ali *et al*., 2000). Among various water parameters for a successful aquaculture practice, dissolved oxygen content in water is the most critical parameter. Oxygen is vital for all organisms living in water and having aerobic type of respiration. One of the ways through which this is maintained in a fish hatchery is by aeration. Water aeration is the process of increasing or maintaining the oxygen saturation in both natural and artificial environments. Any procedure by which oxygen is added to water can be considered a type of water aeration. A good aeration system provides many benefits such as increased production and performance, along with a healthy environment for the fish (Ojeikere and Okonji, 2020).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of Study Area

This study was carried out in Ovia North-East and Ovia South-West local government areas of Edo State. Ovia North-East Local Government Area has its headquarters in Okada town and it has an area of 2,301 square kilometres. It is bounded by longitude $5^{o}\ 45'$ and $6^{o}\ 15'$ and latitude $5^{o}\ 15'$ and $6^{o}\ 45'$ southern province of Edo state. The major communities in the Local Government Area are Okada, Uhen, Utese, Okokhuo, Uhiere, Isiuwa, Ekiadolor, Oluku, Iguoshodin, Utoka, Oghede, Egbeta, Ora, and Ogbese. The main river, Ovia River flows through several of the communities in the LGA. Ovia North-East Local Government Area has a population of 153, 849 (according to the 2006 census), with a mix of urban and rural settlements. The main occupation includes fishing, farming, and trading. The local economy of the area is driven by agriculture, fishing, and small-scale industries, with the area known for its production of fish, palm oil, and cassava.

Ovia South-West lies is situated in the southern part of Edo State, and is bounded by longitude $5^{o}21'$ and $5^{o}11'$ and latitude $6\,^{o}34'$ and $6\,^{o}3'$. It has its headquarters in Iguobazuwa town. The major communities in the Local Government Area include Abozumamwen, Aghobahi, Aifesoba, Evboba, Iguatakpa, Iguobazuwa, Iguogun, Isokponba, Igueze, Obaretin, Ofunama, Okokpon, Udo, Ugbogui, Umaza, and Usen. It has an area of 2,803 square kilometres and a population of 135,356 (according to the 2006 census). The region consists of surface and ground water resources. The surface water resources include major rivers and streams such as Okada

River, Igbogo River, Iguevinyoba River and Siloko River. The vegetation of the area is rain forest, however, the original vegetation has been undergoing modifications due to settlement expansion, and industrial activities. The map of the study area is shown overleaf in fig. 3.1.

3.2 Sampling procedure and Sampling Size

The non-probability chain referral sampling procedure was employed. This is based on the procedure employed by Badaru *et al*. (2022) in the survey on the recent advances in fish hatchery operations around Sokoto metropolis. Fifty (50) Fish hatchery operators each were selected from Ovia North-East and Ovia South-West local government area of Edo State respectively, making it a sample size of one hundred (100) respondents.

3.3 Data Collection

A well-structured questionnaire consisting of both close and open ended questions was used for the collection of data from the fish hatchery operators in the study area.

The questionnaire covered information categorized into three (3) sections:

- Section A: Socio-economic characteristics of breeder.
- Section B: Management practices of breeder.
- Section C: Production output from hatchery.

The use of questionnaire was aided with an interview schedule for hatchery operators that could not read or write.

Fig. 3.1: Map of Edo state showing study area

Sources: Esri, Garmin, USGS, and Geospatial Links company (2022)

3.4 Sampling Size

A total of 100 questionnaires were administered across the two local government areas. Fifty (50) questionnaires for breeders were used in each local government area of interest. The communities selected and breeders were determined by way of non-probability chain referral sampling procedure.

3.5 Data Analysis

Descriptive statistical tools such as tables, charts, and percentages were used to describe breeders' information. Choices of respondents were subjected to a one-way analysis of variance using the Statistical Package for Social Science (SPSS) Version 15.0. Means were separated where significant difference occurred at $P \leq 0.05$ using Duncan's New Multiple Range Test (DNMRT).

CHAPTER FOUR

4.0 RESULTS

4.1 Demographic characteristics of respondents

Table 4.1 shows the demographic characteristics of respondents. The results indicate that the majority of respondents (94.9%) were male, while only 5.1% were females. Regarding age distribution, most respondents (51.9%) were between 30 – 39 years old, followed by 22.8% aged 40 – 49 years, 21.5% aged 20 -29 years, and 2.5% aged above 50 years. Only 1.3% of respondents were younger than 20 years.

In terms of marital status, 75.9% of respondents were married, 21.5% were single, while 2.5% were either separated or divorced. Educational level varied, with 59.0% of respondents having completed secondary education, 28.2% having attained tertiary institution, 10.3% having primary education, and 2.6% having no formal education.

Table 4.1: Demographic characteristics of respondents

Variable	Category	Percentage (%)
Gender	Male	94.9
	Female	5.1
Age	Below 20 years	1.3
	20 – 29 years	21.5
	30 – 39 years	51.9

	40 – 49 years	22.8
	Above 50 years	2.5
Marital status	Single	21.5
	Married	75.9
	Divorced/Separated	2.5
Education Level	No formal education	2.6
	Primary School	10.3
	Secondary School	59.0
	Tertiary Education	28.2

4.2 Socioeconomic characteristics of respondents

Christianity was the predominant religion among respondents, with 86.1% identifying as Christians, followed by 12.7% who were Muslims. A minority (1.3%) practiced other religions. Household sizes varied, with 54.4% of respondents living in households with 1 – 5 members, 44.3% in households with 6 – 10 members, and 1.3% in households with 11 – 15 members. Primary occupation included fish farming (87.2%), fishing (7.7%), and trading (5.1%).

Membership in cooperative society was relatively low, with only 25.3% of respondents participating in cooperatives. All the 25.3% respondents who are cooperative members cited access to funds (100%) as primary advantage. However, a significant portion (74.7%) reported no involvement with cooperative societies.

When it came to source of business capital, most respondents (53.2%) relied on personal savings, cooperative loans accounted for 25.3%, bank loans contributed 13.1%, and loans from family and friends were the least common source, used by 8.4% respondents.

The respondents' breeding experience ranged from 1 – 30 years. Nearly half (48.1%) of the respondents had 1 – 10 years of experience, 40.5% had 11 – 20 years, 10.1% had 21 – 30 years, and only 1.3% had over 30 years of experience. In regards to hatchery ownership, the majority of respondents (87.3%) owned hatcheries, while 12.7% did not.

The socioeconomic characteristics of respondents are summarized in table 4.2.

Table 4.2: Socioeconomic characteristics of respondents

Variable	Category	Percentage (%)
Religion	Christianity	86.1
	Islam	12.7
	Others	1.3
Household Size	1 – 5 members	54.4
	6 – 10 members	44.3
	11 -15 members	1.3
Primary occupation	Fish farming	87.2
	Fishing	7.7
	Trading	5.1
Membership in Cooperative	Yes	25.3
	No	74.7

Benefits of Cooperative	Access to funds	100
	Security	0
Source of Capital	Personal savings	53.2
	Cooperative Loans	25.3
	Family/Friends	13.1
	Bank Loans	8.4
Breeding experience	1 – 10 years	48.1
	11 – 20 years	40.5
	21 – 30 years	10.1
	Over 30 years	1.3
Ownership of Hatchery	Yes	87.3
	No	12.7

4.3 Hatchery management practices

Hatchery management practices varied among respondents. Water quality management techniques included regular flushing or flow-through systems (73.2%), oxygenation (25.6%), and filtration (2.2%). Temperature regulation methods showed that most respondents (78.2%) used insulation materials to maintain optimal hatchery conditions, while 21.8% used heating systems. Feeding techniques were predominantly manual, with 97.4% of respondents employing manual feeding schedules. Only 2.6% used automatic feeding technique.

Predation control measures were well-practiced, with 97.5% of respondents using netting and screening to protect their hatchlings, while only 2.5% use chemical deterrents. Disease prevention strategies included the use of probiotics, which was reported by 94.9% of respondents, and selective breeding for disease resistance, reported by 5.1%.

To prepare fish for market or transfer to grow-out facilities, 68.8% of respondents practiced sorting, while 31.2% employed feeding withdrawal and acclimatization of fish before transfer.

The results on hatchery management practices are shown in Table 4.3.

Table 4.3: Information on hatchery management practices

Variable	Category	Percentage (%)
Water quality management	Flow-through	73.2
	Oxygenation	25.6
	Filtration	2.2
Temperature regulation	Use of insulation materials	78.2
	Heating systems	21.8
Feeding techniques	Manual feeding	97.4
	Automatic feeding	2.6
Predation control measures	Netting and screening	97.5
	Chemical deterrent	2.5
Disease prevention strategy	Use of probiotics	94.9
	Disease resistant breeding selection	5.1
Fish transfer method	Sorting	68.8
	Feeding withdrawal and acclimatization	31.2

4.4 Broodstock management practices

All broodstock-related practices are summarized in Table 4.4. The majority (92.3%) of respondent owned broodstock ponds. Broodstock selection was conducted entirely through physical observation, with 100% of the respondents using this method.

Most respondents (97.5%) reused their broodstock after spawning. The recovery period before reusing female broodstock was typically 3 – 4 months for 89.7% of respondents, while 5.7% allowed a recovery period of 1 – 2 months, and 4.6% extended their recovery to 5 – 6 months.

The ratio of male to female broodstock during spawning was predominantly 1:2 (77.2%), while 22.8% used a 1:3 ratio. Male broodstock were not always sacrificed after spawning, with 59.7% of respondents opting to reuse males, while 40.3% sacrificed them after use.

Table 4.4: Broodstock-related management practices

Variable	Category	Percentage (%)
Broodstock Selection	Physical Observation	100.0
	Genetic screening	0
	Breeding trials	0
Broodstock Reuse	Yes	97.5
	No	2.5
Recovery Period	1–2 months	5.7
	3–4 months	89.7
	5–6 months	4.6
Male-to-Female Ratio	1:2	77.2

	1:3	22.8
	1:1	0
Male Usage	Reused	59.7
	Sacrificed	40.3

4.5 Production output from hatchery

Respondents primarily produced both fingerlings and juveniles, as reported by 92.2% of respondents. In terms of fish species produced, most hatcheries produced multiple species including *Clarias gariepinus and Heterobranchus bidorsalis*, with 97.5% of respondents confirming this practice. The specific traits bred for included both growth performance and disease resistance, as noted by 97.5% of respondents.

Monthly production capacities varied, with 74.4% of respondents reporting capacities of 10,000 – 30,000 fingerlings, while 25.6% produced between 5,000 – 10,000 fingerlings.

Information on production output from hatcheries is shown overleaf in table 4.5.

Table 4.5: Information on production output from hatcheries

Variable	Category	Percentage (%)
Life stage of fish produced	Fingerlings only	7.8
	Both fingerlings and juveniles	92.2
Fish species produced	*Clarias gariepinus* only	2.5
	Both *Clarias gariepinus and Heterobranchus bidorsalis*	97.5
Traits fish are bred for	Disease resistant	2.5
	Both Fast growth rate and disease resistant	97.5
Monthly production capacity	5000 – 10000	25.6
	10000 – 30000	74.4

4.6 Constraints faced in hatcheries

The most significant constraint faced by respondents was poor water quality leading to fry mortality, reported by 55.7% of respondents. Financial inadequacy was identified as a challenge by 27.9% of respondents, while feed availability and cost was reported by 13.9%. Lastly, theft was mentioned by only 2.5% of respondents as a challenge in hatchery operations. These findings are summarized in fig. 4.1 below.

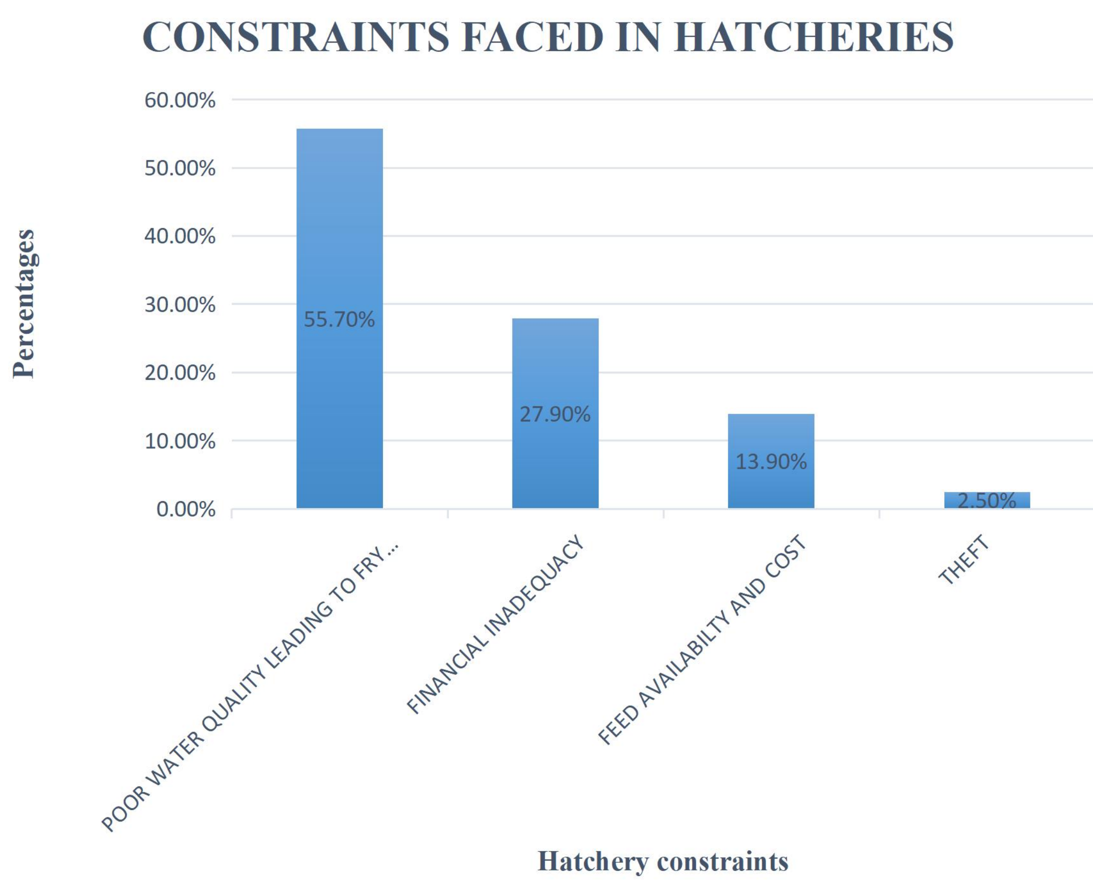

Fig. 4.1: A bar chart illustrating the percentages of respondents affected by each constraint in hatchery operations.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Demographic characteristics of respondents

5.1.1 Gender distribution

The study revealed that most of fish hatchery operators in Ovia North-East and Ovia south-west LGAs are males, while only a few are females. This significant gender disparity indicates that fish seed production in the region is largely dominated by men. Similar trends have been observed in previous studies, such as Badaru *et al.* (2022), who reported that 90% of commercial fish hatchery operators in Sokoto metropolis were male, with only 10% being female. Likewise, Adeoye *et al.* (2020) found that while women actively participate in fish processing and marketing, they are rarely involved in hatchery operations due to the physical demands of the work, limited access to capital, and societal norms that discourage them from engaging in aquaculture production.

The low participation of women in hatchery operations has implications for economic development and productivity in the sector. Nwosu *et al.* (2021) highlighted that Nigeria's fisheries sector is gender-biased, with men dominating prominent positions such as ownership, control, and access to productive resources. Women are often relegated to processing and marketing roles, limiting their potential contributions to other areas of the sector. To address this disparity, government and non-governmental organizations should implement targeted training programs to equip women with the necessary skills for hatchery management. Additionally, providing financial mechanisms, such as microfinance schemes and grants, can encourage female participation by alleviating capital constraints.

5.1.2 Age distribution of hatchery operators

The age distribution among fish hatchery operators in Ovia North-East and Ovia South-West LGAs shows that most of them are in their 30s, followed by those in their 40s. A smaller proportion falls within the 20s age range, while only a few are above 50 years old. This indicates that fish seed production is largely driven by individuals in their productive years.

Several studies including Ikenga *et al*. (2023), have found that aquaculture is primarily driven by individuals between the ages of 30 – 50, as this group possesses both the physical strength and financial stability to invest in fish farming. The relatively high number of respondents in the 20 – 29 age bracket is a positive sign, indicating that younger individuals are increasingly interested in aquaculture. This could be due to increased awareness of the profitability of fish seed production, government initiatives promoting youth involvement in agriculture, and the rising unemployment in other sectors.

However, the low participation of those above 50 years could suggest that older individuals find hatchery operations too demanding. Additionally, older farmers may lack the willingness to adopt new technologies that improve fish seed production efficiency. According to Kumar *et al*. (2018), technology adoption in aquaculture is highest among young farmers, as they are more open to innovation and change. To sustain the industry, policies should focus on retaining younger participants while providing support mechanisms for older farmers, such as mechanized systems that reduce labor intensity.

5.1.3 Marital status of respondents

The results showed that most respondents were married, followed by those who were single, with only a few being divorced or seperated. Married individuals are more likely to be economically stable and committed to long-term business ventures. According to Amaegberi and Oyintonbra (2023), married farmers are more likely to reinvest profits into their businesses due to family responsibilities. The financial stability associated with marriage could explain why a significant number of respondents own hatcheries and are involved in fish seed production. On the other hand, single respondents may face challenges in obtaining capital, as financial institutions often perceive unmarried individuals as high-risk borrowers. In contrast, divorced or separated individuals may experience financial instability, limiting their ability to expand their hatchery businesses.

Marriage also plays a role in labor availability. In many cases, spouses contribute to hatchery operations, either by assisting with feeding, monitoring water quality, or performing administrative tasks. This informal labor contribution can significantly reduce operational costs. Government interventions aimed at supporting single and divorced individuals in aquaculture, such as microloans and training programs, could help increase their participation and success in fish seed production.

5.1.4 Educational level of respondents

Education is of significant importance in aquaculture, particularly in adopting improved hatchery management practices. The findings revealed that most respondents had completed secondary school, followed by those with tertiary education. Fewer had only primary education, while a very small number had no formal education. The high literacy rate is promising, as it suggests that most respondents possess the basic skills required to understand modern hatchery techniques, record-keeping, and water quality management. Educated farmers are more likely to adopt innovative aquaculture practices, such as genetic selection for broodstock improvement, the use of probiotics for disease control, and efficient feeding techniques.

The relatively low percentage of respondents with tertiary education could indicate limited exposure to advanced aquaculture techniques. The FAO's State of World Fisheries and Aquaculture 2020 report emphasizes that higher education levels among fish farmers can lead to increased productivity due to better technical knowledge. However, one important finding here is that education does not necessarily correlate with hatchery ownership. Even respondents with limited formal education successfully operated hatcheries, demonstrating that experience and hands-on learning can sometimes compensate for a lack of academic qualifications. For those with only primary education or no formal education, training programs and extension services will be essential in enhancing their knowledge and skills. Government and non-governmental organizations should consider organizing workshops and training on hatchery best practices, water quality management, and sustainable fish seed production techniques.

5.2 Socioeconomic characteristics of respondents

5.2.1 Religious affiliation of respondents

The study found that Christianity was the predominant religion among respondents, followed by Islam, while only a few practiced other religions. This religious composition reflects the broader demographic pattern of the study area, as Christianity is the dominant religion in southern Nigeria, where the study was carried out.

Religion plays an influential role in fish farming and cooperative engagement. However, religious beliefs do not necessarily affect the technical aspects of hatchery management, as fish farming practices are generally dictated by economic, environmental, and biological factors.

5.2.2 Household size of respondents

Household size is important in fish seed production because it can influence labor availability, production capacity, and financial stability. The study found that most respondents had household sizes of 1–5 members, followed closely by those with 6–10 members, while only a few had 11–15 members. In Nigeria, the average household size ranges from 5 to 6 individuals per family (National Bureau of Statistics, 2020), which is consistent with the findings of this study. Household members contribute to farming activities, thereby reducing the need for hired labor and lowering operational costs. Larger households may provide more free labor for tasks such as hatchery maintenance, fish sorting, feeding, and harvesting. However, larger families also come with increased financial responsibilities, which may limit the reinvestment of profits into hatchery expansion.

Studies have shown that fish farmers with smaller household sizes tend to hire labor, which can increase production costs, whereas those with larger families rely more on unpaid family labor (Sule *et al*., 2002).

5.2.3 Primary occupation of respondents

The results indicated that most respondents were primarily engaged in fish farming,with fewer involved in fishing and trading. The dominance of aquaculture as the primary occupation aligns with the growing trend of fish farming in Nigeria, which has been driven by the declining availability of wild fish stocks and the increasing demand for protein-rich food. The shift from capture fisheries to aquaculture has been widely documented (FAO, 2020), as natural water bodies are becoming over-exploited due to population pressure and environmental degradation.

The small percentage of respondents involved in capture fisheries suggests that wild fishery resources are still relevant, albeit secondary to aquaculture. In some cases, fishermen supplement their income by integrating fish farming into their activities. The presence of traders among respondents also indicates that fish marketing plays a role in hatchery operations, as some fish farmers are directly involved in selling their produce.

5.2.4 Membership in cooperative societies

The study found that a minority of respondents were members of cooperative societies, while the majority did not participate. This low participation rate is concerning because cooperative membership has been shown to improve access to credit, technical knowledge, and bulk purchase discounts on feeds and equipment (Uloh *et al*., 2023). Cooperatives can help in mitigating financial constraints by providing low-interest loans, facilitating group purchases, and offering collective marketing opportunities. However, the reluctance to join cooperatives could stem from distrust, lack of awareness, or previous negative experiences with poorly managed cooperatives. To encourage greater participation, government agencies and non-governmental organizations (NGOs) should work towards strengthening cooperative management and increasing awareness of their benefits.

5.2.5 Sources of business capital

Access to capital is a critical factor for the success of fish seed production enterprises. The study found that most respondents relied on personal savings, while others accessed cooperative loans, bank loans, or borrowed from family and friends. The heavy reliance on personal savings suggests that many farmers face challenges in accessing institutional credit. This is consistent with findings by Smith and Doe (2024), which highlight that high-interest rates, stringent collateral requirements, and bureaucratic processes often deter small-scale farmers from securing bank loans. The relatively low percentage of respondents who accessed bank loans indicates that commercial financial institutions may not be the preferred funding source for fish farmers. Instead, cooperative loans are more popular, as seen in those who benefited from them. Cooperative loans often come with lower interest rates and fewer bureaucratic hurdles, making them more accessible to small-scale hatchery operators.

5.2.6 Breeding experience of respondents

The breeding experience of respondents ranged from 1–30 years, with most having 1–10 years of experience, followed by those with 11–20 years. Fewer had 21–30 years of experience, and only a very small number had over 30 years. Experience is an important determinant of success in hatchery management, as it influences farmers' ability to optimize breeding techniques, manage water quality, and prevent diseases. The fact that nearly half of the respondents had less than 10 years of experience suggests a relatively young industry with many new entrants. While this is promising for sector growth, it also means that ongoing training and extension services are needed to ensure best practices. The presence of a significant number of experienced hatchery operators is beneficial, as they can mentor younger farmers.

5.2.7 Hatchery ownership

The study found that most respondents owned hatcheries, which is a strong indicator of business stability, as those who own their facilities have greater control over production processes. Ownership allows farmers to optimize breeding cycles, implement better water management strategies, and experiment with improved broodstock selection techniques. The few respondents without hatchery ownership likely depend on renting hatchery facilities or operating on a partnership basis. While this can reduce initial investment costs, it also presents challenges such as limited operational control, increased costs over time, and dependency on the hatchery owner's management practices. To encourage more hatchery ownership, government and financial institutions should offer low-interest loans, grants, and subsidies for infrastructure development. Additionally, technical support and training should be provided to ensure that newly established hatcheries adhere to best practices in fish seed production.

5.3 Hatchery management practices

5.3.1 Water quality management

Water quality is one of the most important factors in hatchery operations, as poor water conditions can lead to high mortality rates, stunted growth, and increased disease outbreaks. Poor water quality is a leading cause of fish mortality in hatcheries, and maintaining optimal parameters such as pH, temperature, and ammonia levels is critical for survival. The study revealed that the majority of hatchery operators in the study area employed flow-through systems, which help maintain water quality by constantly replenishing water, and reducing the risk of oxygen depletion, thus ensuring optimal conditions for development. Studies by Okomoda *et al.*

(2016), indicated that frequent water renewal led to better water quality, which in turn improved the growth rates and survival of *Clarias gariepinus* fingerlings.

A smaller proportion of respondents used oxygenation techniques, which involve the use of aerators, air pumps, or diffusers. Oxygenation is particularly important in intensive hatchery operations, where high stocking densities increase the risk of oxygen depletion. However, in contrast to large-scale hatcheries, where aeration is a standard practice, the relatively lower adoption in the study area suggests that financial constraints and access to aeration equipment may limit its use among small-scale operators.

Filtration was the least commonly used water quality management method, with only a small percentage of respondents adopting it. Filtration systems are more commonly found in commercial hatcheries, where advanced recirculating aquaculture systems (RAS) are used to remove fine particles, excess nutrients, and harmful bacteria from water. The low adoption of filtration suggests that hatchery operations lack the financial capacity to invest in advanced water treatment systems.

5.3.2 Temperature regulation methods

Temperature regulation is essential in hatchery operations, as fluctuations can negatively impact embryo development, hatch rates, and fry survival. The study found that respondents employed two main methods for temperature control including the use of insulation materials and use of heating systems. The use of insulation materials as the dominant strategy suggests that most hatchery operators rely on passive temperature control methods. Insulation materials such as tarpaulins, plastic sheets, and shading structures are commonly used in tropical aquaculture to reduce fluctuations in water temperature. This passive approach to temperature regulation is cost-effective and is particularly useful in outdoor hatcheries where direct exposure to sunlight and ambient temperature changes can impact fish development. Studies have shown that maintaining stable water temperatures enhances fry survival rates, particularly in *Clarias gariepinus* and *Heterobranchus bidorsalis*, which thrive at temperatures between 26°C and 30°C (Okunsebor and Ayuba, 2015).

On the other hand, heating systems, though less commonly used, are more effective in controlled environments such as indoor hatcheries or in areas where temperature drops significantly at night. Electrical heaters, immersion heaters, or gas-powered heating devices are commonly used in more intensive hatchery systems. However, access to electricity or alternative energy sources may be a limiting factor, especially for rural hatcheries with unreliable power supply. Government intervention, such as subsidies for solar-powered heating systems, could enhance efficiency while reducing operational costs.

5.3.3 Feeding techniques

Proper feeding is fundamental for optimal growth and survival of hatchlings. The study found that most respondents practiced manual feeding, while only a few use automatic feeders. Manual feeding allows hatchery operators to monitor fish feeding behavior, adjust feed quantities based on fish appetite, and minimize feed wastage. However, it is labor-intensive and may lead to inconsistent feeding schedules if not properly managed.

The use of automatic feeders reduces labor intensity. The limited use of automatic feeders may be due to high costs and limited availability.

5.3.4 Predation control measures

Predation is a major challenge in hatchery operations, particularly for fry and juvenile fish. The study revealed that most respondents use netting and screening to protect their stock, while only a few use chemical deterrents. Netting and screening are the most effective and environmentally friendly methods of preventing predation. They serve as physical barriers against birds, amphibians, and other aquatic predators. Studies have shown that netted hatcheries experience significantly lower fry mortality rates compared to unprotected setups (Bevan *et al*., 2002).

The limited use of chemical deterrents suggests that most hatchery operators prefer non-chemical approaches to predation control, possibly due to concerns about water contamination and fish health. Chemical repellents, while effective, can pose risks to health, and may require careful regulation.

5.3.5 Disease prevention strategies

Disease outbreaks can lead to massive losses in hatcheries, affecting fry survival and overall productivity. The study found that respondents used two main disease prevention strategies including the use of probiotics and selective breeding for disease resistance. The high adoption of probiotics is a positive sign, as probiotics improve gut health, enhance immune responses, and reduce dependency on antibiotics.

The low adoption of selective breeding for disease resistance suggests that most hatchery operators do not prioritize genetic improvements for disease resilience. Selective breeding has been widely adopted in advanced aquaculture systems to produce genetically superior broodstock that exhibit higher resistance to diseases (Rakkannan and Priyadarshi, 2023). The low adoption rate may be due to limited knowledge, lack of access to genetically improved broodstock, or financial constraints. Encouraging genetic selection programs and providing access to improved broodstock could enhance long-term hatchery performance and reduce disease-related losses.

5.3.6 Fish transfer methods

The study found that hatchery operators use two primary methods to prepare fish for transfer including Sorting, and feeding withdrawal and acclimatization. The high adoption of sorting indicates that hatchery operators prioritize size grading before transfer. Sorting prevents cannibalism, ensures uniform growth in grow-out facilities, and reduces competition among fish. However, only a few respondents practiced feeding withdrawal and acclimatization, which are essential for reducing stress during transportation. Feeding withdrawal reduces metabolic waste accumulation in transport containers, while acclimatization minimizes temperature and salinity shock. FAO (2020) recommends that fish be gradually acclimated to new environments to prevent transportation-induced mortality. Training hatchery operators on proper transport and acclimatization techniques could further improve survival rates and marketability of fish seed.

5.4 Broodstock management practices

5.4.1 Broodstock selection methods

The study found that all respondents select their broodstock through physical observation. This method involves assessing the health, size, coloration, and body condition of fish to determine their suitability for breeding. Physical observation is the most common selection technique in small- and medium-scale hatcheries, as it does not require sophisticated equipment. However, while effective, it does not account for genetic traits such as growth performance, disease resistance, or reproductive efficiency. In more advanced hatchery systems, broodstock selection is often complemented by genetic screening to enhance desirable traits. However, limited access to genetic testing facilities and high costs may explain why no respondents reported using genetic selection techniques.

5.4.2 Broodstock reuse

The study revealed that most respondents reuse their broodstock after spawning, while only a few discard them. The high percentage of broodstock reuse is an indication of cost-saving strategies among hatchery operators. Reusing broodstock can be advantageous in maintaining a steady supply of fertilized eggs, but it requires careful management to prevent reproductive fatigue. Studies have shown that continuous use of the same broodstock without adequate recovery time can lead to reduced fertility and lower hatch rates (Egwenomhe and Ake, 2016). However, the small percentage of farmers who discard broodstock after a single use may be doing so due to concerns about disease transmission or the need to introduce new genetic lines into their stocks.

5.4.3 Recovery period before reuse

The study found that most respondents allow a recovery period of 3–4 months before reusing their female broodstock, while a smaller proportion opt for 1–2 months. Only a few extend the recovery period to 5–6 months. Recovery time is important in ensuring that female broodstock regain their reproductive capacity before subsequent spawning. The predominant 3–4 months' recovery period aligns with standard aquaculture practices, which recommend at least three months of rest between spawnings for *Clarias gariepinus* to allow for proper gonadal development (Abdel-Nasser and El-Ghobashy, 2000).

Respondents allowing only 1–2 months for recovery may be at risk of reduced egg quality and spawning success. In contrast, those extending recovery to 5–6 months may be prioritizing broodstock longevity over frequent spawning cycles. This approach can be beneficial in ensuring long-term reproductive performance but may reduce the overall seed production capacity of the hatchery.

5.4.4 Male-to-Female ratio

The study found that the majority of hatchery operators in the study area use a male-to-female ratio of 1:2 during spawning, while a relatively smaller proportion use a 1:3 ratio. This ratio aligns with common aquaculture practices, where a higher number of females per male is often recommended to maximize fertilization success and overall fry production.

The 1:2 and 1:3 ratios observed in this study are consistent with findings from other studies on catfish hatcheries. For instance, in African catfish (*Clarias gariepinus*), the recommended broodstock ratio for optimal breeding is typically 1:2 or 1:3, as this increases the likelihood of successful fertilization (Maradun *et al*., 2018). The 1:2 and 1:3 ratios reported in this study suggest that hatchery operators are prioritizing sperm availability while ensuring that individual males are not over utilized to the point of exhaustion.

5.4.5 Male usage after spawning

The findings indicate that most hatchery operators reuse their male broodstock after spawning, while only a few sacrifice them. The practice of sacrificing males after spawning is commonly associated with artificial propagation techniques where male broodstock are sacrificed for sperm extraction, particularly in species like *Clarias gariepinus*, where hand-stripping or testes removal is commonly used. The decision to reuse or sacrifice males depends on several factors, including sperm quality, genetic considerations, and disease prevention. The reuse of males, as seen in the majority of respondents in this study, is a cost-effective practice that allows hatcheries to maximize the lifespan of their broodstock. Research by Tkacheva *et al*. (2020) found that *Clarias gariepinus* males can be reused multiple times if well-managed, as they can produce viable sperm for successive breeding cycles. However, sperm quality may decline over time, necessitating periodic replacement of male broodstock to maintain high fertilization rates.

On the other hand, the respondents who sacrifice males after spawning likely do so to minimize risks of disease transmission and genetic degradation. Continuous reuse of the same male broodstock can lead to inbreeding, which has been reported to reduce hatchability and fry survival rates in hatcheries (Tine *et al*., 2022). Additionally, some hatcheries sacrifice males due to limited space or inadequate facilities to house them separately after breeding. The variation in practices suggests that hatchery operators balance economic factors with genetic and biosecurity concerns when deciding whether to reuse or sacrifice male broodstock.

5.5 Production output from hatchery

The study found that most respondents produce both fingerlings and juveniles, while only a few focus exclusively on fingerlings. Producing both life stages is more economically viable, as it allows hatcheries to cater to different market demands. Hatcheries that produce juveniles often command higher prices because juvenile fish have a higher survival rate when stocked in grow-out systems compared to fingerlings (James *et al*., 2023).

The species produced in the surveyed hatcheries were predominantly *Clarias gariepinus* and *Heterobranchus bidorsalis*, with most respondents reporting production of both species. This finding is consistent with the general preference for these species in aquaculture due to their fast growth rates, hardiness, and adaptability to various environmental conditions (FAO, 1988). The study also found that most respondents breed their fish for both fast growth and disease resistance. The ability to produce large numbers of fry and juveniles with these traits necessary in meeting market demand and ensuring the sustainability of hatchery operations.

In terms of production capacity, monthly production capacities varied with most respondents producing 10,000 – 30,000 fingerlings, while a smaller proportion produced 5,000 -10,000 fingerlings. This variation reflects differences in hatchery size, resource availability, and management practices. While the majority of respondents have relatively high production capacities, those with lower capacities may face challenges in scaling up their operations due to financial or technical constraints.

5.6 Constraints faced in hatcheries

Hatchery operators in the study area reported several challenges affecting production. The most significant constraint was poor water quality, which led to fry mortality. Water quality is a critical factor in hatchery management, as parameters such as dissolved oxygen, ammonia levels, and pH directly impact fry survival rates. Studies by Okomoda *et al*. (2016) have shown that poor water quality is a leading cause of mortality in catfish hatcheries, with fluctuations in parameters like temperature and ammonia concentration leading to mass fry deaths.

Financial inadequacy was also a significant constraint, limiting the ability of hatchery operators to acquire broodstock, feeds, and hatchery equipment. Previous studies such as Ololade and

Olagunju (2013), have highlighted that many small- and medium-scale hatcheries in Nigeria struggle with funding due to high loan interest rates and limited access to credit facilities.

Feed availability and cost remains one of the most significant production costs in hatchery operations. High feed costs can affect profitability and force hatchery operators to use suboptimal diets, which can impact fry growth and survival (Olagunju *et al*., 2024). Another constraint identified was theft. Theft is a common issue in fish farms and hatcheries, particularly in areas where security measures are inadequate. Losses due to theft can significantly reduce profitability and disrupt production cycles. The findings are similar to those of Ideba *et al*. (2013), who reported that theft accounts for substantial financial losses in fish farms, necessitating stricter security protocols.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The findings of this study indicate that fish seed production in Ovia North-East and Ovia South-West LGAs is largely undertaken by middle-aged, experienced, and predominantly male operators. This suggests that the sector requires significant expertise, and gender disparities may be due to socio-economic and cultural factors. Hatchery operations in the area mostly rely on traditional and cost-effective methods, such as passive temperature regulation, manual feeding, netting for predation control, and broodstock reuse. These methods help minimize costs, but may limit efficiency and consistency in seed production.

For disease prevention, probiotics are widely used to enhance fish health. However, selective breeding for disease resistance remains largely underutilized, indicating limited application of advanced hatchery techniques. Economic considerations are the primary drivers of species selection, with operators favoring species that offer high market value and good growth performance. However, limitation in technical expertise, financial constraints, and environmental factors also play significant roles in determining productivity.

Findings from the study has shown that poor water quality leading to fry mortality, theft, feed availability and cost, and financial inadequacy are the constraints facing hatchery operators in the study area. These challenges have hindered the efficiency and expansion of fish seed production in the area. Therefore, addressing these issues could enhance productivity and enhance long-term sustainability in the sector.

6.2 Recommendations

Based on the findings from the study, the following recommendations are proposed:

1. Hatchery operators should take advantage of training and extension services offered by government agencies and research institutes to improve skills in breeding, water quality management, and disease prevention for better seed quality and productivity.
2. Hatchery operators should adopt technologies like automated feeding systems and real-time water quality monitoring to improve efficiency and reduce losses.
3. Financial institutions and policy makers should develop targeted funding schemes, such as low-interest loans, or grants, to enable hatchery operators invest in modern equipments, and improved infrastructure.
4. Further studies should be carried out on other aspects of the fish seed production value chain to enable a comprehensive understanding of the fish seed production in the study area.

REFERENCES

Abdel-Nasser, G., and El-Ghobashy, H. (2000). An assessment of the reproductive performance of wild and captive *Clarias gariepinus. Annals of Agricultural Science, Moshtohor, 55(1), 93-100.*

Adekoya, B.B., Ayansanwo, T.O., Iduwu, A.A., Kudoro, O.A., and Salisu, A.A. (2006). In directory of fish hatcheries in Ogun State. *Ogun State Agricultural Development Programme (OGADEP). Abeokuta, pp: 18.*

Adeoye A.S, Oke O.O, Eniola O. and Jatto K.A. (2020). Assessment of gender roles in fish farming activities among rural farmers in Afijio local government area of Oyo state, Nigeria. *Nigeria Agriculture journal, 51(2), 406–412.*

Adewumi, A. (2015). Aquaculture in Nigeria: Sustainability issues and challenges. *Direct Research Journal of Agriculture Food Science, 3: 12.*

Akankali, J.A., Seiyaboh, E.I., and Abowei, J.N. (2011). Fish Hatchery Management in Nigeria. *Advance Journal of Food Science and Technology, 3(2), 144-154.*

Amaegberi, H., and Oyintonbra, O. P. (2023). Savings and Its Determinants Among Cashew Farmers: Evidence from Dekina Local Government Area, Kogi State, Nigeria. *Iconic Research and Engineering Journals, 7(1), 475–483.*

Amosu, A.O., Hammad, A.M., Togunde, K.A., Joseph, O.O., and Adekoya, A. (2017). Possible aquaculture development in Nigeria: Evidence for commercial prospects. *Journal of Agricultural Science and Technology, B 7, 194-205.*

Atanda, A.N. (2006). Analysis of Freshwater Fish Seed Resources in Nigeria. *Fisheries Society of Nigeria (FISON) Conference Proceedings.*

Aulanier, F., Desprez, D., Napuru, A., and Mikolasek, O. (2010). Role of the private sector in fry and fingerling production in Uganda. *Aquaculture Compendium (118009). Wallingford, UK: CABI.*

Badaru, A.A., Abubakar, Y., and Ibrahim, B. (2022). Survey on the Recent Advances in Fish Hatchery Operations around Sokoto Metropolis. *Journal of Aquaculture and Fisheries, 2(7): 1-5.*

Bevan, D. J., Chandroo, K. P., and Moccia, R. D. (2002). "Predator Control in Commercial Aquaculture in Canada." *University of Guelph Aquaculture Centre Technical Bulletin, 5(1), 1-8.*

Bhuiyan, M.A.B., Haque, S.M., Chakraborty, B.K., Chowdhury, P., and Rahman, M.M. (2019). Collection procedure of carp egg of Halda river along with marketing and economic conditions of the fishermen and other related people. *International Journal of Applied Science, 1-14.*

Bondad-Reantaso, M.G. (2007). Assessment of freshwater fish seed resources for sustainable aquaculture. *FAO Fisheries Technical Paper, No. 501. Rome: FAO.*

Brummett, R.E. (2007). Freshwater seed supply: Africa regional synthesis. In Bondad-Reantaso M.G., ed. Assessment of freshwater fish seed resources for sustainable aquaculture. *FAO Fisheries Technical Paper, No. 501. Rome: FAO. 41-58.*

Bruton, M.N. (1979). The breeding biology and early development of *Clarias gariepinus* (Pisces; Clariidae) in Lake Sibaya, South Africa, with a review of breeding in species of the subgenus Clarias. *Trans. Zool. Soc. Lond., 35: 1-45*.

Busch, R.L. (1985). Channel catfish culture in ponds. In: Channel catfish culture. C.S. Tucker, ed. Amsterdam, *Elsevier, 13-84.*

Central Bank of Nigeria (CBN). (2017). *Annual Report.*

Chondar, S.L. (1980). Hypophysation of Indian Major Carp. *Satish Book Enterprise, Motikatro Agra-3 (India), p. 146.*

Clemens, H.P., and Sneed, K.E. (1957). The spawning behavior of the channel catfish *Ictalurus punctatu*s. *U.S. Fish and Wildlife Serv. Spec. Scient. Rep. Fish., 219.*

De Kimpe, P., and Micha, J.C. (1974). First guidelines for the culture of *Clarias lazer*a in Central Africa. *Aquaculture, 4: 227-248.*

Delince, G.A., Campbell, D., Janssen, J.A.L., and Kutty, M.N. (1987). Seed Supply Lectures presented at ARAC for the Senior Aquaculturists. Course African Regional Aquaculture Centre Port-Harcourt, Nigeria, *United Nations Development Programme Food and Agriculture Organization of the United Nations and Nigerian Institute for Oceanography and Marine Research Project Raf/82/009.*

Egwenomhe, M and Ake, J.E. (2016) 'Recrudescence of spawned female African catfish (Clarias gariepinus), in *2nd University of Benin Annual Research Day (UBARD) Conference,* LSA057, pp. 539 – 542.

Federal Ministry of Agriculture and Rural Development (FMARD). (2012). *Aquaculture Transformation Implementation Plan.*

Federal Ministry of Agriculture and Rural Development (FMARD). (2016). The Agriculture Promotion Policy (2016 - 2020). *Policy and Strategy Document, 59pp*.

Food and Agriculture Organization (FAO). (2010). Fishery and aquaculture country profiles. *The Arab republic of Egypt. Rome: FAO.*

Food and Agriculture Organization of the United Nations (FAO). 2020. The State of World Fisheries and Aquaculture 2020: *Sustainability in Action. Rome.* *https://doi.org/10.4060/ca9229en*

Food and Agriculture Organization. (1988). Selection of species for aquaculture. In Aquaculture production management (Chapter 3). *https://www.fao.org/3/l9805e/l9805e04.htm*

George, F.A.O., Olaoye, O.J., Akande, O.P., and Oghobase, R.R. (2010). Determinants of aquaculture fish seed production and development in Ogun State, Nigeria. *J. Sustain. Dev., 12(8): 22-34.*

Ginsburg, A.S. (1987). Egg cortical reaction during fertilization and its role in block to polyspermy. *Sov. Sci. Rev. Physiol. Gen. Bio., 1: 307-375.*

Hogendoorn, H. (1981). Controlled propagation of the African Catfish, *Clarias lazera* (CandV) IV. Effect of feeding regimes in fingerling culture. *Aquaculture, 4: 123-131*.

Ideba, E. E., Enyenihi, G. E., and Williams, M. E. (2013). Economic Analysis of Fish Farming in Calabar, Cross River State, Nigeria. *Greener Journal of Agricultural Sciences, 3(7), 542-549.*

Ike, N., and Onuegbu, R. (2007). Adoption of Aquaculture Technology by fish farmers in Imo state of Nigeria. *Journal of Technology Studies, 33: 57-63.*

Ikenga, V. U., Ogisi, O. D., and Gbigbi, T. M. (2023). Profitability of Aquaculture by Gender in Delta State, Nigeria. *Direct Research Journal of Agriculture and Food Science, 11(6), 144–152.*

James, S. E., Doherty, B., Cox, S. P., Pearsall, I. A., and Riddell, B. (2023). Size and timing of hatchery releases influence juvenile-to-adult survival rates of British Columbia Chinook (*Oncorhynchus tshawytscha*) and coho (*Oncorhynchus kisutch)* salmon. *Canadian Journal of Fisheries and Aquatic Sciences, 80(4), 700–718.* *https://doi.org/10.1139/cjfas-2022-0121*

Kudo, S., Linhart, O., and Billard, R. (1994). Ultrastructural studies of sperm penetration in the egg of the European catfish (*Silurus glanis*). *Aquatic Living Resources, 7: 93-98.*

Kumar, G., Engle, C., and Tucker, C. (2018). Factors Driving Aquaculture Technology Adoption. *Journal of the World Aquaculture Society, 49(3), 447–476*

Mair, G. (2002). Supply of good quality fish seed for sustainable aquaculture. *Aquaculture Asia, 7(2), 25.*

Maradun, H., Abdulmalik, M. E., Mohammed, H., Lawal, M. O., Aliyu, A. B., and Jibril, A. A. (2018). Effect of different male-female broodstock ratios on the induced breeding performance of *Clarias gariepinus*. *Journal of Aquaculture and Fisheries Management, 5(1), 45–52.*

Mulokozi, D.P., Mmanda, F.P., Onyago, P., Torbjȍrn, L., Tamatamah, R., and Berg, H. (2020). Rural Aquaculture: Assessment of its contribution to household income and farmers' perception in selected districts, Tanzania. *Aquaculture Economics and Management, DOI: 10.1080/13657305.2020.1725687.*

Nasir, M.A., Farida, S., Laurat, T., Nafisat, M.D., and Awawu, D. (2014). Survey of Functional and Non-functional Hatcheries in Jigawa State, Nigeria. *Journal of Fisheries and Aquatic Science, 9(6): 473-477.*

Neira, R. (2010). Genetic improvement in aquaculture: A review of breeding programs. *Aquaculture, 306(1-4), 1-14.* https://doi.org/10.1016/j.aquaculture.2010.05.004

Nwosu, F. M., Fakoya, K. A., Akintola, S. L., and Abiodun-Solanke, M. F. (2021). Women in fisheries and aquaculture in Nigeria: Introducing the bootstrap in the roadmap. *International Journal of Food Science and Agriculture, 5(6), 570–573.*

Ofuoku, A.U., Olele, N.F., and Emah, G.N. (2008). Determinants of adoption of improved fish production technologies among fish farmers in Delta State, Nigeria. *Journal of Agricultural Education and Extension, 14: 297-306.*

Oghenetejiri, D.A., and Ademuyiwa, H.O. (2017). Awareness of improved hatchery management practices among fish farmers in Lagos State. *Agricultura Tropica et Subtropica, 50(1), 19-25.*

Ojeikere, B.A., and Okonji, V.A. (2020). Effect of Varied Hours of Aeration on the Spawning Success of African catfish. *International Journal of Fisheries and Aquatic Studies, 8(2): 126-131.*

Okomoda, V. T., Tiamiyu, L. O., and Iortim, M. (2016). The effect of water renewal on growth of *Clarias gariepinus* fingerlings. *Croatian Journal of Fisheries, 74(1), 25-29.* https://doi.org/10.1515/cjf-2016-0005

Okunsebor, S. A., and Ayuba, V. O. (2015). Effect of temperature on fertilization, hatching, and survival rates of *Heterobranchus bidorsalis* in the laboratory. *British Journal of Applied Science and Technology, 7(4), 386-392.*

Olagunju, F.I., Adesiyan, I.O., and Ezekiel, A.A. (2007). Economic Viability of catfish Production in Oyo State, Nigeria. *Journal of Human Ecology, 21(2): 121-124*.

Olagunju, O. F., Kristofersson, D., Tómasson, T., and Kristjánsson, T. (2024). Farm strategies and characteristics influencing profitability in Nigerian catfish aquaculture: Lessons on resilience during economic crisis and COVID-type shock. *Journal of the World Aquaculture Society, 55(5), 3058–3075.* https://doi.org/10.1111/jwas.13058

Olanrewaju, A.N., Agbelege, O.O., Daddy, F., and Okoye, F.C. (2010). Fish Hatchery Survey in Borno State, Nigeria. *Proceedings of the 25th Annual Conference of the Fisheries Society of Nigeria, October 25-29, 2010, Lagos, Nigeria.*

Olaoye, O.J., Idowu, A.A., Omoyinmi, G.A., Ezeri, G.N., and Oke, A.O. (2011). Factors Determining Fish Hatchery Operations in Ogun State, Nigeria. *Journal of Agricultural Extension and Rural Development, 3(10), pp. 172-181.*

Ololade, R.A., Olagunju, F.I. (2013). Determinants of access to credit among rural farmers in Oyo State, Nigeria. *Global Journal of Science Frontier Research Agriculture and Veterinary Sciences, 13(2), 17-22.*

Oluwatayo, I.B., and Adedeji, T.A. (2018). Comparative analysis of technical efficiency of catfish farms using different technologies in Lagos State, Nigeria. A data envelopment analysis (DEA) approach. *Agric and Food Secur, 8(8)*.

Onyekuru, N.A., Ihemezie, E.J., and Chima, C.C. (2019). Socio-economic and profitability analysis of catfish production: A case study of Nsukka Local Government Area of Enugu State, Nigeria. *Journal of Tropical Agriculture, Food, Environment and Extension, 18(2): 51-58.*

Otubusin, S.O. (1998). Sustainable Utilization of Nigeria's aquatic/wetland resources: Fish cage, pen and enclosure systems options. *In S.O. Otubusin et al. (Eds). Sustainable utilization of Aquatic/Wetland Resources. University of Agriculture, Abeokuta, UNAAB, Abeokuta, Nigeria, pp. 69-74.*

Rakkannan, G., and Priyadarshi, H. (2023). Selective breeding for disease resistance in aquaculture: Current methods and future directions. *Biotica Research Today, 5(1), 45-47.*

Richter, C.J.J., and Van den Hurk, R. (1982). Effect of 11-desoxycorticosterone-acetate and carp pituitary suspension on follicle maturation in the ovaries of the African catfish, *Clarias lazera* (C. and V.). *In: Proc. Symp. Reproductive Physiology of Fish. C.J.J. Richter, H.J.Th. Goos, eds PUDUC, Wageningen, 147-150.*

Richter, C.J.J., Vivecn, W.J.A.R., Eding, E.H., Sukkel, M., Rothuis, A.J., Van Hoof Van, M.F.P.M., Der Berg, F.G.J., Van Oordt, P.G.W.J. (1987). The significance of photoperiodicity, water temperature and an inherent endogenous rhythm for the production of viable eggs by the African catfish, *Clarias gariepinus*, kept in subtropical ponds in Israel and under Israeli and Dutch hatchery conditions. *Aquaculture, 63: 169-185.*

Schoonen, W.G.E.J., Granneman, J.C.M., Lambert, J.G.D., Van Oordt, P.G.W.J. (1987). Steroidogenesis in the testes and seminal vesicles of spawning and non-spawning African catfish, *Clarias gariepinus*. *Aquaculture, 63: 77-88.*

Shikuku, K.M., Tran, N., Joffre, O.M., Islam, A.H.M.S., Barman, B.K., Ali, S., and Rossignoli, C.M. (2021). Lock-ins to dissemination of genetically improved fish seeds. *Agricultural Systems, 188: 103042.*

Smith, J. A., and Doe, R. L. (2024). Barriers to Agricultural Financing in Developing Economies. *International Journal of Sustainable Agriculture, 18(3), 45-59. https://doi.org/10.1080/14735903.2024.2329388*

Smitherman, R.O., Dunham, R.A., and Tave, D. (1983). Review of catfish breeding research 1969-1981 at Auburn University. *Aquaculture, 33: 197-205*.

Sule, A. M, Ogunwale, S. A. and Atala, T. K. (2002). Factors affecting adoption on fishing in Jebba Lake Community. *Journal of innovation among fishing entrepreneurs Agricultural Extension 6, 48 – 60.*

Tambasen-Cheong, M.V.P., Tan-Fermin, J.D., Garcia, L.M.B., and Baldevarona, R.B. (1995). Milt-egg ratio in artificial fertilization of the Asian freshwater catfish, *Clarias macrocephalus*, injected salmon gonadotropin-releasing hormone analogue and Domperidone. *Aquatic Living Resources, 8: 303-307.*

Tine, M., Ndiaye, F., Bale, K., Maguelemou, L. D., and Sene, M. A. (2022). Effects of inbreeding depression on the success of artificial reproduction in the African catfish *Clarias gariepinus* (Burchell, 1822). *International Journal of Aquaculture and Fisheries Sciences, 8(2), 45-53. https://doi.org/10.17352/2455-8400.000077*

Tkacheva, I., Kuzov, A., Polienko, S., and Polyakov, V. (2020). Intravital method for obtaining genital products from the male African catfish (*Clarias gariepinus). E3S Web of Conferences, 210, 07011. https://doi.org/10.1051/e3sconf/202021007011*

Tsai, C., Islam, M.N., Karim, M.R., Rahman, K.U.M.S. (1981). Spawning of major carps in the lower Halda River, Bangladesh. *Estuaries, 4: 127-138.*

Tucker, G.S., and Robinson, E.H. (1990). *Channel catfish farming handbook. Avi Book, New York, 454 p.*

Tunde, A.B., Kuton, M.P., Oladipo, A.A., and Olasunkanmi, L.H. (2015). Economic Analysis of Cost and Returns of Fish Farming in Saki-East Local Government Area of Oyo State, Nigeria. *Journal of Aquaculture Resource Development, 6(2): 306-310.*

Uloh, E. V., Ume, S. I., Nwose, D. I., and Onyeke, A. C. (2023). Determinants to cooperative societies' access to government agricultural inputs intervention program in Anambra State, Nigeria. *Sustainability, Agri, Food and Environmental Research, 11, Article e02299. https://doi.org/10.7770/safer.v11i1.2299*

Van der Waal, B.C.W. (1985). Stripping male *Clarias gariepinus* standard. *Aquaculture, 40: 137-142.*

APPENDIX I

DEPARTMENT OF AQUACULTURE AND FISHERIES MANAGEMENT
FACULTY OF AGRICULTURE
UNIVERSITY OF BENIN
BENIN CITY, EDO STATE

TOPIC: FISH SEED PRODUCTION PRACTICES IN OVIA NORTH-EAST AND OVIA SOUTH-WEST LOCAL GOVERNMENT AREAS OF EDO STATE

Dear Respondents,
The purpose of this research is to take a survey on the fish seed production practices in Ovia North-East and Ovia South-West Local Government Areas of Edo State. This research also ascertains the management practices employed and the productive output of the hatchery. Kindly tick and answer carefully where appropriate. You are assured the information provided shall be kept strictly confidential and used only for the study.

AYENI EBENEZER VICTOR
Researcher

INSTRUCTIONS: Please tick the boxes if applicable (Yes or No) and supply an answer where your opinions are needed.

SECTION A: SOCIO-ECONOMIC CHARACTERISTICS OF BREEDER

1. **Gender**: Male ☐ Female ☐
2. **Age**: Below 20 years ☐ 20-29 years ☐ 30-39 years ☐ 40-49 years ☐ 50 years and above ☐
3. **Marital Status**: Single ☐ Married ☐ Separated/Divorced ☐ Widowed ☐ Widower ☐
4. **Level of Education**: No formal education ☐ Primary education ☐ Secondary education ☐ Tertiary education ☐ Others (specify): _____________
5. **Religion**: Christianity ☐ Islam ☐ Others (specify): _____________
6. **Household size**: 1-5 ☐ 6-10 ☐ 11-15 ☐ Greater than 15 ☐
7. **Breeding Experience**: 1–10 years ☐ 11–20 years ☐ 21–30 years ☐ Greater than 30 years ☐
8. **Primary Occupation**: Fish Farming ☐ Trading ☐ Fishing ☐ Others (specify): _____________
9. **Membership of Cooperative Society**: Yes ☐ No ☐
10. **Benefits of joining a cooperative**: Access to funds ☐ Security ☐ Others (specify): _____________
11. **Source of Business Capital**: Loan from banks ☐ Co-operative society (osusu) ☐ Personal savings ☐ Loan from family and friends ☐
12. **Do you own the hatchery?** Yes ☐ No ☐

SECTION B: MANAGEMENT PRACTICES OF BREEDER

13. **How do you manage water quality in your hatchery?** Filtration systems ☐ Flow-through ☐ Oxygenation ☐ Others (specify): _____________
14. **How do you regulate temperature in your hatchery?** Heating systems ☐ Cooling systems ☐ Use of insulation materials ☐
15. **Do you have a broodstock pond?** Yes ☐ No ☐
16. **Which method do you primarily use for selecting broodstock?** Genetic screening ☐ Physical observation ☐ Breeding trials ☐ Others (specify): _____________
17. **Do you care for your broodstock before using them?** Yes ☐ No ☐
18. **What feeding practices do you employ for your hatchlings?** Manual feeding schedules ☐ Automatic feeders ☐ Others (specify): _____________
19. **How is predation controlled?** Netting and screening ☐ Chemical deterrent ☐ Others (specify): _____________
20. **What measures do you take to prevent and control diseases in your fish population?** Disease-resistant breeding selection ☐ Use of probiotics ☐ Others (specify): _____________
21. **How do you prepare your fish for market or transfer to grow-out facilities?** Sorting ☐ Sedation and handling protocols ☐ Feeding withdrawal and acclimatization of harvested fish ☐
22. **Do you re-use your broodstock after spawning?** Yes ☐ No ☐
23. **How long is the recovery period before the female broodstock are reused?** Specify: _____________
24. **Are the males sacrificed per spawning?** Yes ☐ No ☐

SECTION C: PRODUCTION OUTPUT FROM HATCHERY

25. **What species of fish are being produced in your hatchery?** Clarias gariepinus ☐ Heterobranchus bidorsalis ☐ Both A and B ☐ Others (specify): _____________
26. **Which life stage of fish does your hatchery primarily focus on?** Fry ☐ Fingerlings ☐ Juveniles ☐ All of the above ☐
27. **Which specific trait or characteristics are the hatchery's fish bred for?** Fast growth rate ☐ Disease resistance ☐ Both A and B ☐ Others (specify): ___________
28. **How many males and females do you use per spawning?** 1:2 ☐ 1:1 ☐ 1:3 ☐ Others (specify): _____________
29. **What is the estimated monthly production capacity of the hatchery?** Less than 5000 fish ☐ 5000–10,000 fish ☐ 10,000–30,000 fish ☐ Others (specify): _____________
30. **What is the major constraint you face in your hatchery?** Survival of fry ☐ Feed availability and cost ☐ Financial inadequacy ☐ Theft ☐ Others (specify): _____________