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EFFECTS OF BROODSTOCK SEX PAIRING RATIOS AND RESTING PERIODS OF THE NILE TILAPIA ***OREOCHROMIS NILOTICUS*** (LINNAEUS, 1758) ON FRY PRODUCTION

BY

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DECLARATION

This dissertation is the result of research work undertaken by Oblie Naa Ayele Eleanor in the Department of Marine and Fisheries Sciences, University of Ghana under the supervision of Dr. Samuel Addo. I do hereby declare that the dissertation consists entirely of my own work and that no part of it has been previously published or submitted for a degree or diploma elsewhere.

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ABSTRACT

The Nile tilapia, *Oreochromis niloticus* (Linnaeus, 1758) forms about 80% of farmed fish in Ghana. However, the unavailability of its seed all year round for culture is a major constraint. This study evaluated the effects of varying male to female broodstock pairing ratios of 1:1, 1:2 and 1:3 with resting intervals of 0, 3 and 7 days on fry production performance of the Akosombo strain of the Nile tilapia at the Ashaiman Aquaculture Demonstration Centre, Ghana. Nine (9) treatments were arranged according to a 2 x 3 factorial design with three replicates giving a total of 27 spawning hapas (1 m^3). Male and female brooders of mean body weight (200±50 g and 171±23.7 g respectively) were paired according to the three different sex ratios. Water quality parameters for temperature and DO were taken daily while's pH, salinity and ammonia were measured weekly. The total mean fry output for the sex pairing ratios (1:1, 1:2, 1:3) were 716±344, 973±325 and 723±577 respectively. The total fry output for 0, 3 and 7 days of resting were 1503±868, 2030±637 and 3051±1054 respectively with an observed 35% (3 days rest) and 103% (7 days rest) fry production increment over the 0 resting treatment. With respect to the combined effect of varying sex ratios and resting periods, the highest mean fry production (701±405) was attained under the 7 days resting period at a pairing ratio of 1:2. Although results subjected to ANOVA showed no significant differences ($p>0.05$) among the treatments, the relatively high reproductive performance observed for broodstock pairing ratio 1:2 and resting period of 7 days under this study confirms that it is a more efficient broodstock management technique for an increased Nile tilapia fry production.

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DEDICATION

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

The human population is well in excess of 9 billion with the accompanying challenge of provision of food and support of livelihoods (Garcia and Rosenberg 2010). The demand for seafood has increased because it is deemed a healthier animal protein source however the world's fishing areas have reached their maximum potential for capture fisheries production. From 1961, the yearly worldwide development of fish intake has been twice as much as the population growth although capture fishery production has relatively plateaued since the late 1980s (Aguilar-Manjarrez, 2018). In 2015, global marine fish catch was 81.2 million tonnes whiles in 2016 recorded 79.3 million tonnes indicating almost 2 million tonnes decline. Globally, most capture fisheries have been completely exploited or overexploited to satisfy the increasing demand for fish as a result of population growth, rising income and increasing urbanization (Finegold, 2009). Out of the total 171 million tonnes of fish produced in 2016, 88% was utilized for direct human consumption.

Aquaculture accounts for the continuing appreciable growth in fish supply for human intake. The global aquaculture industry is expected to produce more than 102 million metric tonnes annually by 2050 to sustain the current per capita consumption rate (Merino *et al*., 2012). Aquaculture could fill the global fish supply – demand gap and potentially reduce the pressure on capture fisheries. Aquaculture is currently responsible for approximately 47 percent (80 million tonnes) of the total aquatic animal food production in 2016 meant for human consumption and is increasing at a yearly growth rate of 5.8%. (FAO, 2018). As a fast developing segment of agriculture, it is anticipated that aquaculture will provide nearly two-thirds of the fish meant for global intake by 2030. Africa's contribution to global aquaculture is only 2.2% although it has the best climatic conditions for the development of a major aquaculture industry to make fish cheaper and accessible for improved nutrition of its citizens.

In 2016, it is estimated that about 59.6 million people are involved in the prime sector of capture fisheries and aquaculture; 19.3 million in aquaculture and 40.3 million in capture fisheries (FAO, 2018). Aquaculture has the potential of expansion with the influx of people into the industry especially crop farmers who are converting their poor soils and farm lands into fish farms to have a source of livelihood to support their families. Capture and inland fisheries contributed 87.2 and 12.8% of the global overall fish production correspondily. Global production of farmed fish depends increasingly on inland aquaculture mostly in fresh water environments. Inland Aquaculture is commonly done in ponds and also in raceways, tanks, pens and cages. Over 75% of the farmed fresh water fish in China are produced in earthen ponds and in the U.S. almost all of the grown catfish are raised in earthen ponds as pond culture is the most dominant aquaculture facility (Klinger and Naylor, 2012).

Fresh water fishes contribute largely to the overall aquaculture production globally (Taylor, 2016) and the Nile tilapia, *Oreochromis niloticus* (Linnaeus, 1758) is the second most cultured species after carps. Nile tilapia is an important worldwide species indigenous to the Nile River, Africa and the Middle East generally (Gupta and Acosta, 2004). It is being cultured in nearly 85 countries globally and approximately 98% of tilapia grown in these countries is produced outside their native habitats. Out of the 70 species of tilapia, nine species are used worldwide with the Nile tilapia accounting for 83% of the overall global tilapia production (Gupta and Acosta, 2004, 2004). The world's production of tilapia attained 4,507,002 tonnes in 2012, signifying 10.2% of total cultured fish produced. It is preferred for culture due to its rapid growth, good and tasty flesh quality, and tolerance to some extent against harsh conditions, successful reproductive strategies and ease of fingerling production under captivity. Nile tilapia is usually grown in ponds, floating mesh enclosures (hapas), cages as well as tanks (Bhjuel, 2000). In Africa, small-scale culture facility mostly rely on earthen ponds.

The steadily growing importance of Nile tilapia culture has compelled improvements in broodstock management techniques necessary for the production of quality fingerlings in adequate numbers to meet production goals of farmers. The hapa-in-pond breeding system is mostly used in the Phillipines and Thailand (Bhujel *et* al., 2001). Hapas are preferred for production because its design allows the female to be retrieved with minimal disturbance to inspect for eggs or yolk sac fry. Frequent harvesting of seed and handling of broodstock is done with ease in the hapa breeding system. Moreover it is easier to construct and relatively cheaper than the concrete tanks. Nile tilapia fry production is usually attained by aggregate spawning of males and females in big hapas hanging in earthen ponds (Bhujel, 2000). For this mass spawnings, territorial conduct and reproductive rivalry among males may result in a huge difference in reproductive success amid individual males. Mating techniques in Nile tilapia ranges from lone pair to multiple sex pairing in order to produce fry (Fessehaye *et al.*, 2006). The reproductive success of Nile tilapia is influenced by broodstock conditioning, sex ratios, stocking density, stage of development, size, resting periods, diet and feeding rate (Tahoun *et al.*, 2008).

Nile tilapia culture is inhibited by uncontrolled reproduction resulting in the production of low-priced fish below marketable sizes during harvest. The males grow faster with uniformity in size than the females hence the development of sex reversal techniques to produce all male to curtail early maturation and unwanted reproduction. All male sex reversed Nile tilapia fingerlings shorten the culture period for multiple production cycles in a year.

According to Phelps and Popma (2000), various methods are used to distort the sex ratios and increase the percentage of males in a population. Optimum resting periods and sex ratio enhances hatchery efficiency and seed production.

1.2 Justification

The Fisheries sector contributes 1.1% to GDP and 6.1% to the Agricultural gross domestic product which generates income for 10% of the Ghanaian population (GSS, 2017). Fish forms about 60% of total animal protein intake of Ghanaian diet with per capita consumption of 26 kg/yr. The annual fish output of 465,356.65 metric tonnes fell short of the 1,132,332.04 metric tonnes required in 2016 (MOFAD, 2017). With levelled landings from capture fisheries as against an increasing population, the deficit of 666,669.75 metric tonnes is set to increase further if aquaculture production is not increased significantly.

In Ghana, cage culture contributes over 88% of the overall aquaculture production with tanks and ponds accounting for 7.3% and the remaining 4.7% represents dams, dugouts and reservoirs (MOFAD, 2017). The significant contribution of cage culture to aquaculture in Ghana could further improve if fingerling production from hatcheries could be increased to meet the demand of out-growers and at affordable price.

Although the Nile tilapia forms about 80% of farmed fish species in Ghana, grow-out farmers face the challenge of procuring quality seed in large quantities to meet their demand. It is estimated that about 50 million fingerlings is needed on annual basis to offset the fish seed deficit in Ghana (Rurangwa *et al.*, 2015). The poor seed quality from our hatcheries results in smaller market size fish at harvest which is unsatisfactory to consumers and leads to lower profit margins for fish farmers (Sarfo, 2007).

The inability of our hatcheries to produce good quality fingerlings in large quantities is attributed to inadequate knowledge and skill in proper broodstock management techniques. Low production of Nile tilapia seeds has also been blamed on very low broodstock density, poor spawning techniques, inadequate broodstock nutrition, high fry mortality, improper resting periods and unsuitable sex ratios (Salama, 1996). The use of appropriate broodstock pairing ratios and resting periods could enhance fry production and subsequently decrease the cost of production (Adel, 2012).

Fry production at the Aquaculture Demonstration Centre of the Ministry of Fisheries and Aquaculture Development in Ashaiman, Ghana is currently done using the sex pairing ratio of 1 male to 3 females under a no rest system, recorded a production efficiency of 20% in 2018 (Lutterodt, 2018).

1.3 Objective of Study

The primary aim of this research was to help improve the efficiency of Nile tilapia fry production at the Aquaculture Demonstration Centre, Ashaiman, Ghana.

Specific objectives were to:

1. Ascertain the effects of varying brood stock ratios on the Nile tilapia fry production.
2. Determine the contribution of varying broodstock resting periods on Nile tilapia fry production.
3. The combined effect of pairing ratios and pairing ratios on fry production.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Tilapia Production

Tilapia is the second most farmed fish species after carps and comprises approximately 10% of the total global fish farming (Gupta, 2004). It is cultured in about 85 countries globaly and nearly 98% of tilapia grown in these countries is produced outside their native habitats. Out of the 70 species of tilapia, nine species are used worldwide with the Nile tilapia representing 83% of total global tilapia production. Nile tilapia *Oreochromis niloticus* (Linnaeus, 1758) is a globally important species indigenous to the Nile River, Africa as well as the Middle East in general (Shelton 2002). It is deemed a low priced commodity with high nutritional and health benefits; provides livelihood and ensures food security. With capture fisheries declining amidst an increasing population, fish requirement can only be met through Aquaculture.

Africa's 2.2% contribution to aquaculture globally is not appreciable although fish consumption is very high in this part of the world. The most cultured species on the continent are catfish, tilapia and Nile perch (Balirwa, 2007). There are large number of river systems across the continent which could support a major aquaculture industry with significant contribution to global fish production. In Africa, aquaculture of tilapia contributes about 19% of the global tilapia production with 5.5 million tonnes and Egypt is the leading producer of about 800,000 tonnes (Ansah *et al.*, 2014). In Sub-Saharan Africa however, aquaculture production of tilapia has significantly improved at a yearly average rate of 20% over the past 10 years. In 2012, around 150, 000 tons of tilapia was produced from countries such as Ghana, Zambia, Uganda, Nigeria, Kenya and Zimbabwe which have achieved remarkable growth in commercial aquaculture production in recent years (Ridler and Hishamunda, 2001).

The major species contributing to aquaculture production in Ghana are *O. niloticus* and *Clarias gariepinus*. The *O. niloticus* forms about 80% of all farmed fish in Ghana and the rest of the 20% constitutes *C. garepienus* and *Heterotis niloticus*. The country's geo-ecological climate is suitable for Nile Tilapia culture in order to increase fish supply from the aquaculture industry in Ghana. Nile tilapia is desired for culture because of its positive aquacultural characteristics such as its suitability to variety of pond farming conditions, high reproductive rate, disease resistance, good survival and growth rate (Onumah *et al.*, 2010).

Increased production in aquaculture is dependent on availability of good quality seed from good breeders. Mating techniques in Nile tilapia ranged from lone pair to multiple sex pairing (Yonas *et al.*, 2006).

In intensive hatcheries, *O. niloticus* fry production is usually attained by stocking aggregate spawning of males and females stocked in big hapas hanging in earthen ponds, collecting seed from the females' mouth and hatching them artificially in tank-based hatcheries (Little *et al.*, 1997).

Collection of eggs or fry from the mouths of incubating females reared in large hapas suspended in fertilized ponds and incubating them artificially has been found to be commercially viable.

2.2 Nile Tilapia Culture in Ghana

The most predominant Nile tilapia strain cultured in Ghana is the Akosombo strain, which is a genetically improved form of the wild strain. The "Akosombo strain" developed by the Water Research Institute (WRI) in conjunction with World Fish Center grows 30% faster than its wild ancestors (Daily Graphic 2012). The Akosombo strain was developed in 1999 after choosing a rapidly growing fish for more than eight generations to produce faster and bigger fishes for good profit margins (Rurangwa *et al.*, 2015). The adoption of the new strain as brood stock has increased fingerling production and was projected to heighten tilapia production by ten-fold by 2015 (Rurangwa *et al.*, 2015). The significance of this strain to the aquaculture industry is an increased productivity, greater income, reduced labour and fish feed cost for increased access and affordability. The strain is exported to the West African sub-region such as Burkina Faso, Nigeria and Cote d'Ivoire for commercial fish farming since it reaches market size in five months faster than eight months of regular tilapia (Ansah *et al.*, 2014).

2.3 Nile Tilapia Hatchery Systems

Successful production of high quality fingerlings requires preparation of spawning areas or hatcheries. Hatchery systems for Nile tilapia seed production include open ponds, tanks and fine mesh nets (<1.6 mm) hapas suspended in ponds (Asase *et al.*, 2016). Concrete tanks are widely used as spawning units but hapas are preferred because they are cheaper, easier to construct and easier to manipulate during fry harvest and handling of broodstock (Bhjuel *et al.*, 2007). Hapas require continuous maintenance and cleaning due to fouling. The hapa system for the spawning of tilapia is dependent on the density of the broodstock, sex pairing ratio, broodstock replacement, water turbidity, wind action and regulating the water level. The paired hapa system where the broodstock are retained in a larger inside mesh and the swim up fry in an outer fine mesh hapa to reduce cannibalism does not enhance reproductive performance (Tahoun *et al.*, 2008). Collection of eggs or fry inside the maternal brooder's mouth gives much higher seed output compared to unmanaged reproduction in ponds. The hatchery operator is required to have the relevant technical knowledge and skills and equipment to run the facility (Ngugi *et al.*, 2007).

2.3.1 Breeding in Hapa

Breeding hapas are arranged in rows with spacing of 1.5m apart to enable water circulation. The hapa breeding system is more efficient but involves high labour. The stocking ratio for males to females is 1: 1 to 4 with 1:2 or 1:3 females to males being the commonly used. The hapa method practised in south east of Asia involves inspecting the brooders' mouth every five days to collect eggs. Swim up fry are collected with fine-mesh (Bhjuel, 2013). Eggs or yolk sac fry collected are hatched using artificial incubators within 2 to 3 days.

2.4 Broodstock Management

Nile Tilapia males and females are differentiated by a protruding cone – shaped genital papilla with two openings in the males' whiles the females have a small rounded genital papilla with three openings. Sexual maturity is a function of age, size and environmental conditions. Sexual maturity in Nile tilapia is usually attained at 5- 6 months at a size of 20 cm to 30 cm in a natural environment. However farmed tilapia can reproduce at a size of 8 cm to 13 cm at 20 g to 40 g (de Graaf, 2013). *Oreochromis niloticus* is a mouth brooder and the breeding procedure commences with the male establishing his niche, digging a cavity-like breeding grounding and guarding his niche. The ready-to-spawn female releases eggs into in the nest, and just after fertilization by the male, takes the eggs into her mouth. The female brooder nurtures the eggs in her mouth and nurses the fry after hatching till the yolk sac is absorbed; this is done in 1 to 2 weeks depending on temperature. The fry upon their release may find their way back into their mother's mouth when they feel threatened. Nile tilapia being a maternal mouth brooder can only harbour fewer number of eggs per spawn as compared to majority of the other pond fishes. In natural waters, tilapia show large variations in its reproductive characteristics. According to Kunda *et al* (2014), tilapia have a tendency of producing more but smaller sized oocytes under culture conditions than in natural conditions. *O. niloticus* males individually build and protect a niche within a defined breeding ground (a 'lek') where females lay their eggs (Weber, 2010). Males are capable of fertilizing eggs from a series of females; females can spawn continuously provided there's no fall in temperature (FAO, 2009). Tilapia are asynchronous breeders which spawn all through the year in the warm season of the tropics and subtropics. A brooder of 90-300 g is estimated to produce 500 eggs per spawning at 25^{o}C

A sustainable seed production is largely dependent on the proper management of the broodstock. The broodfish parameters for hatchery production efficiency are choice of brood stock, diet, fertility, stocking density, sex pairing ratio and environmental state. Fry production increases if brood fish are hand sexed, separated and rested after spawning.

2.4.1 Conditioning of Breeders

Conditioning of breeders is done in large separate hapas suspended in fertilized ponds at least two weeks prior to stocking. Putting potential female breeders together could enhance spawning synchrony through exchange of social stimuli in order to enhance uniformity of size and age of offspring. Breeding intensity is significantly influenced by the broodstock state and the preparedness of the female to brood. The breeders are fed complete feed of 30% crude protein using a feeding rate of 2 to 5 per cent of their body weight (El-Sayed, 2006).

2.4.2 Broodstock Selection

The selection of breeders has an effect on the quantity and quality of seed produced. Reproductive performance of tilapia could be influencd by size of broodstock, past spawning activities, production conditions, and the choice of broodstock. Retrieval and handling of fish during selection of potential breeders is done with ease in hapas. The choice of age and size of potential female and male breeders should be close to reduce mortalities. Seed production efficiency decreases with the female brooder's age and consecutive spawnings. According to El-Sayed (2006) small broodfish are less prolific and less capable at incubating eggs and protecting their fry. The number of eggs produced is proportionate to the female's body weight and variances in fecundities (seed per female per spawning season) may be attributed to variation in age and size (Macintosh, 1995). According to Rashid *et al* (2013), *O. niloticus* is a mouth brooder in nature with small gonads and can produce less than 700 eggs. The big sized females can produce much more eggs per spawn relative to the smaller ones; nevertheless, smaller females spawn more eggs per unit gram of their body weight (Watanabe, 1985). Campos-Mendoza *et al* (2004) reported that bigger females can hold more eggs and fry and yet have less spawning. A female brooder weighing 100 g will produce around 100 eggs per spawn whereas a female of 600-1000 g could spawn 1000 to 1500 eggs. In the River Nile 547 to 3670 eggs were produced by a female having a total length of 12 to 27 cm whereas 482 to 3982 eggs were recorded by females of total length between11 to 22 cm (El-Kasheif et. al., 2013)

2.4.3 Broodstock Density and Sex Ratio

Optimum stocking density and male to female proportion enhances hatchery efficiency and seed production. According to Mires (1982), too low or too high broodstock density produces low seed. Little (1989) also pointed out that increasing the stocking density of broodstock in small hapas could reduce seed production. Mires proposed that 'male coercion' is a key factor in having an increased breeding intensity. A high broodfish density results in hostility and combat among males resulting in less courtship, egg fertilization and gestation (Ridha and Cruz, 1999). Bhujel (2000) moreover reported that mucus produced from tilapia has a constituent that could result in auto allergic reactions and hinder breeding at higher broodstock densities. The proportion of breeding females is therefore inversely proportional to the stocking density of the brooders because of chemicals or behavioural influences (Lovshin, 1982). Tharwat (2007) recommended 5 fish per metre square for optimal seed output in hanging mesh enclosures (hapas). El-Sayeed (2006) discovered that 4 fish per metre square had better seed output and spawning consistency compared to 8 and 12 fish per metre square at 29^{o}C. The relative weight and sizes of male and female brooders are equally vital as the sex pairing ratio (Bhujel, 2000).

Optimum sex ratios for tilapia broodstock is a determinant of seed output. Suboptimal ratio causes a decrease in seed output, inefficient use of resources and a rise in variable cost. The relatively stocking of high proportion of females is mostly practised as males are polygamous such that they can mate with several females in a day (Peterman, 2011). Romana-Eguia (2013) indicated that the male: female ratio ranges from 1:5 in ponds to 1:10 in tanks and hapas. A ratio of 1 :< 3 however seems ideal (El sayeed, 2012). Siddiqui and Al-Harbi (1997) discovered a higher fry production by keeping a female to male proportion of 3:1 and 2:1 of three broodfish/m^2 at 28^{o}C, whereas Lovshin (1982) reported that a ratio of 1:2 was better than 1:1 or 2:1 in *O. niloticus*.

2.4.4 Broodstock resting periods

The broodstock management of most hatcheries is to continuously use the same brooders all through the course of production until after a noticeable decline in fry production. Resting of tilapia broodstock requires keeping males and females in separate units, for a time of rest in between spawning usually at a high stocking density 2.5 kg per metre square with good feeding rates (Ambali, 1990). According to Lovshin and Ibrahim (1988), replacement of exhausted male and female broodstock with those conditioned for 21 days amounted to a 16% increment in egg and fry output for a period of 105 spawning relative to either no broodfish replacement or female alone replacement. Conditioning of females has been noted for improvement of spawning synchrony and seed production. Nevertheless, conditioning beyond 10 days was not beneficial compared to shorter periods (Lovshin *et al.*, 1988). Furthermore, acclimatizing for 20 days amounted to 18% reduction in seed production/m^2/day (Abou-Zied, 2015). Broodstock are usually rested intermittently until they are ultimately replaced to boost fry production. The separation of broodstock by sex enhances the spawning condition of *O. niloticus*, however ovulation and resorption of eggs may occur during long rest. According to Peters (1983) the resorption of properly-developed ova in the ovary is due to the absence of spawning opportunity. *O. niloticus* can conserve these kind of eggs for just about one week. Also, Little (1993) discovered that females that have been conditioned together with males that have been conditioned resulted in an increased seed output and spawning frequency compared to just conditioned females with unconditioned males. This could be as a result of the energetic participation of males that have rested already in courtship. Besides fertilization capability of sperm drastically reduced from around 90 percent to 20 percent with increasing mating occurrence; this could be attributed to the production of immature spermatozoa (Bhujel, 2000). Conversely, prolonging the resting of males could have adverse effects on sperm quality since spermatozoa are continually produced and released into the lumen of the testis and sperm quality is likely to drop with time after discharge. According to Abou-Zied (2015), a short period of 5-10 days of resting males just like females might be the optimum.

Even though tilapia spawns asynchronously in the tropics, an advancement in controlling fry production by separation of broodfish conditioning and breeding could immensely affect economic viability of hatchery operations (Little, 1989). However, a proper conditioning of females involves stocking densities that preclude territory establishment that usher in the concluding stages of courtship and ovulation (Ridha and Cruz, 1999).

2.5 Feeding Effect on Spawning

The size at first maturation improved with rising nutritional protein levels. The spawning rate for each female and amount of eggs per spawn is determined via protein level and feeding rate administered to the brooder (Siddiqui *et al.*, 1998). Bhujel (2007) established that the optimum feeding rate was 2% of fish weight per day. The protein level is dependent on the dietary requirement of the brooder. High nutritional protein levels in feed meant for tilapia broodfish apparently leads to a rise in the number of eggs per spawn and also minimises the spawning periodicity (Bhujel, 2000, Little and Hulata, 2000). The extrinsic nutrition of brooders offers the vital nutrients necessary for developing the gonads of females and enhancing the quality of the seed produced (El-Sayeed, 2006). Thus an inadequate feeding of broodfish will amount to reduced reproductive success and seed output (Bhujel, 2000). During inadequate food provision, female mammals as well as female brooders of fishes may be capable of producing and raising their offspring via draining body reserves. However, during intensive farming high feeding standards are adhered to in order to maintain reproductive performance (Ross, 2000). Protein percentages of 25 and 30 results in broodstock reaching their sexual maturity at larger sizes (El-sayeed *et al.*, 2003).

2.6 Fry Harvesting

The natural mouth brooding method of Nile tilapia seed production gives varying developmental stages of fry (Glenney, 2002). Fry inter-harvesting interval of 14 days at temperatures above 25^{o}C ensures a high number of yolk sac and swim up fries in hapas (Asaase, 2010). The inter-spawning interval is reduced when clutch (cohort eggs) or fry are removed: production is increased from an average of one spawn to two spawns per month (Rana, 1988). However the number of seed per clutch or condition of seed may be reduced. After effective egg production and incubation, severe damage of eggs as well as fry may be experienced during harvest in seed production systems. The hapa breeding system allows for easy separation and retrieval of fry with less disturbance and mortalities of breeders and fry. An extended harvesting period may facilitate cannibalism and predation resulting in less fry being collected.

2.7 Water Quality Management

Fish is a cold-blooded animal whose survival and growth is a function of water temperature. Water quality parameters affect the survival, reproduction, growth, and production of aquaculture species (Caldini *et al.*, 2011). Water quality parameters necessary for Nile tilapia culture and reproduction include dissolved oxygen, pH, ammonia, nitrite, turbidity, alkalinity, salinity, light intensity and photoperiod.

Environmental factors play a vital role in fish gonadal maturation, spawning for hatchery production efficiency. Good water quality can be achieved by maintaining the right balance between feed input and assimilative capacity of water.

Prime growth of Nile tilapia occurs at a temperature of 26^{o}C to 28^{o}C. Fish body temperature, which is synonymous to the temperature of water has influence on vitality, behaviour, feed intake, development and procreation of fish. Mortalities could occur with sudden variations in temperature or continuous high temperatures beyond the required range (Khater *et al.*, 2017). Reproductive performance is notably low at temperatures above 35^{o}C and lower than 22^{o}C (Yadav, 2006). The number of eggs produced reduces when the temperature of water increases and relative fecundity declines considerably with increasing body weight (Rashid *et al.*, 2013). Uptake of feed is lowest at lower temperature hours of the day resulting in feed wastage and deteriorating water quality (Endut *et al.*, 2010) ; growth and reproductive performance is heavily affected (Caldini *et al.*, 2011). Deep hapas in deep ponds are used to reduce the effect of very cold water temperatures (Ali *et al.*, 2013).

Dissolved oxygen plays a vital role in the feeding, metabolic rate, growth and spawning efficiency of fish (Mallya, 2007). There are diurnal fluctuations in oxygen levels with supersaturation during the day and oxygen depletion at night. Diurnal fluctuations are known to be caused by photosynthesis, respiration and diel fluctuations. The lowest level of dissolved oxygen which is good for producing fish in ponds has been recommended to be at 5 mg/l (Das, 2000, 2001) as cited by Choudhary and Sharma (2018).

Nevertheless, Nile tilapia can withstand dissolved oxygen as low as 0.1-0.5 mg/l for varying time periods. A fall in dissolved oxygen affects bigger than smaller fish, which are able to get to oxygen richer water at the surface, mostly for a short time.

The pH of water in pond experiences varied fluctuations and in open waters the daytime changes in pH is usually basic in afternoon and mostly acidic right before the day breaks. El-Sayed (2006) stated that optimal growth of fish occurs at pH ranges of 7.5 and 8.5. High or low water pH could result in behavioural modifications, destruction of gill epithelial cells, decrease in the efficiency of excreting nitrogenous waste and high mortality. Van Dijk *et al.* (1993) confirmed that metabolic rate and oxygen consumption is reduced when the water is acidic.

Ammonia concentrations should be around 0.5 mg/l or less with emphasis on keeping pH levels low at an optimum value of 6.5 amidst high DO levels. Overfeeding leads to a pile of uneaten feed at the bottom, which decays to release ammonia which increases the total ammonia nitrogen levels as well as the load on nitrifying bacteria and filter in holding facilities (Someville *et al.*, 2014).

Salinity of water is recounted to affect the reproduction of tilapia whereas the salinity tolerance is affected by fish size and age. Development of the gonads and spawning of Nile tilapia takes place at salt levels of 17-29‰, whiles the inception of reproduction delayed with rising water salinity from 25 to 50‰ reproduction absolutely ceases at salinity over 30‰ (El-Sayed, 2006). Just recently, it was established that spawning performance and protein requirement were meaningfully affected by water quality (El-Sayed *et al.*, 2003).

The photoperiod is crucial in encouraging growth of fish, rate of metabolism, sexual maturation and reproduction (El –Sayeed 2006). According to Ridha and Cruz (2000), low light intensity causes reduced spawning action as less energy is dedicated to somatic growth. The development of the gonad, fertility and spawning rate are improved with increasing photoperiod (El-Sayeed, 2001). The best reproductive performance for optimum seed production is 18h a day (Ridha and Cruz, 2010), however, Campos Mendoza *et al.* (2004) suggested that a normal daylight length of 12 hours will produce larger eggs, higher total fecundity and relative fecundity.

CHAPTER THREE

3.0 MATERIALS AND METHOD

3.1 The Study Site

The study was carried out at Ashaiman Aquaculture Demonstration Centre (A.A.D.C) (Fig 3.1), a government fish hatchery situated in the Greater Accra Region of Ghana from December, 2018 to March, 2019 when climatic conditions were favourable for spawning and average daily water temperature was 26-28°C. The Centre lies between Longitude N 05.669 77 ^{0} and Latitude W 000.05 394 (Fig 3.1). The Centre was set up about 46 years ago under the Fisheries Directorate of the Ministry of Food and Agriculture but is now run by Ministry of Fisheries and Aquaculture Development (MOFAD). It forms about 5% of the irrigational dam area which was earmarked for agricultural activities. The dam is the main source of water supply for this breeding centre and the surrounding community. The Centre's culture facilities include sixteen (16) nursery tanks of 50 m^2 each, four (4) earthen ponds of 150 m^2 for holding brooders, incubation room for egg hatching, and 5 (five) earthen ponds (1500 m^2 each, the largest being 2100 m^2) for grow-out and fingerling production (Plate 3.1).

The core mandate of A.A.D.C is the multiplication and dissemination of tilapia and catfish fingerlings. The centre also provides extension services and on-farm training to beneficiary fish farmers and students.

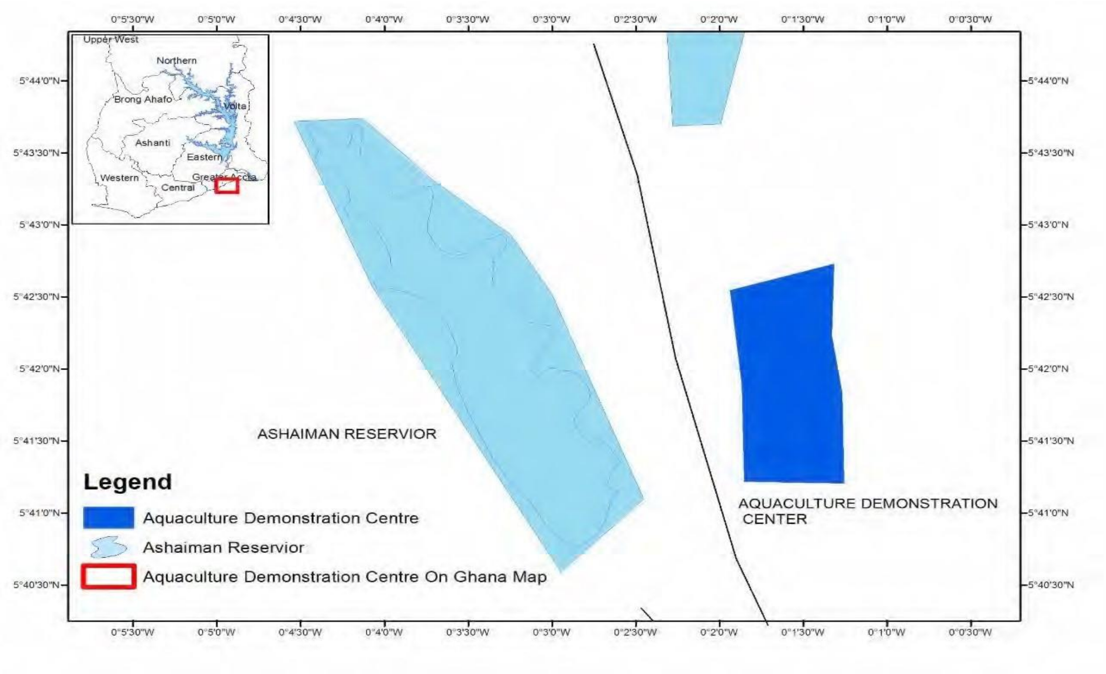

Figure 3.1: Map of Ghana showing the Ashaiman Aquaculture Demonstration Centre

Plate 3.1: Aerial view of the Ashaiman Aquaculture Demonstration Centre

3.2 Experimental Design

Nine (9) treatments were arranged according to a 2x3 factorial design with three replicates giving a total of 27 spawning hapas ($1m^3$) (Fig 3.2). The Nine (9) treatments were carried out over a period of 70 days to ascertain their effect on seed production. The treatments were male to female pairing ratios of 1:1, 1:2, 1:3 at resting intervals of 0, 3 and 7 days. Each treatment had three replicates. The Akosombo strain of the Nile tilapia (*O. niloticus*) brood fish obtained from the Aquaculture Research and Development Centre (ARDEC), Akosombo, Ghana were used for this experiment.

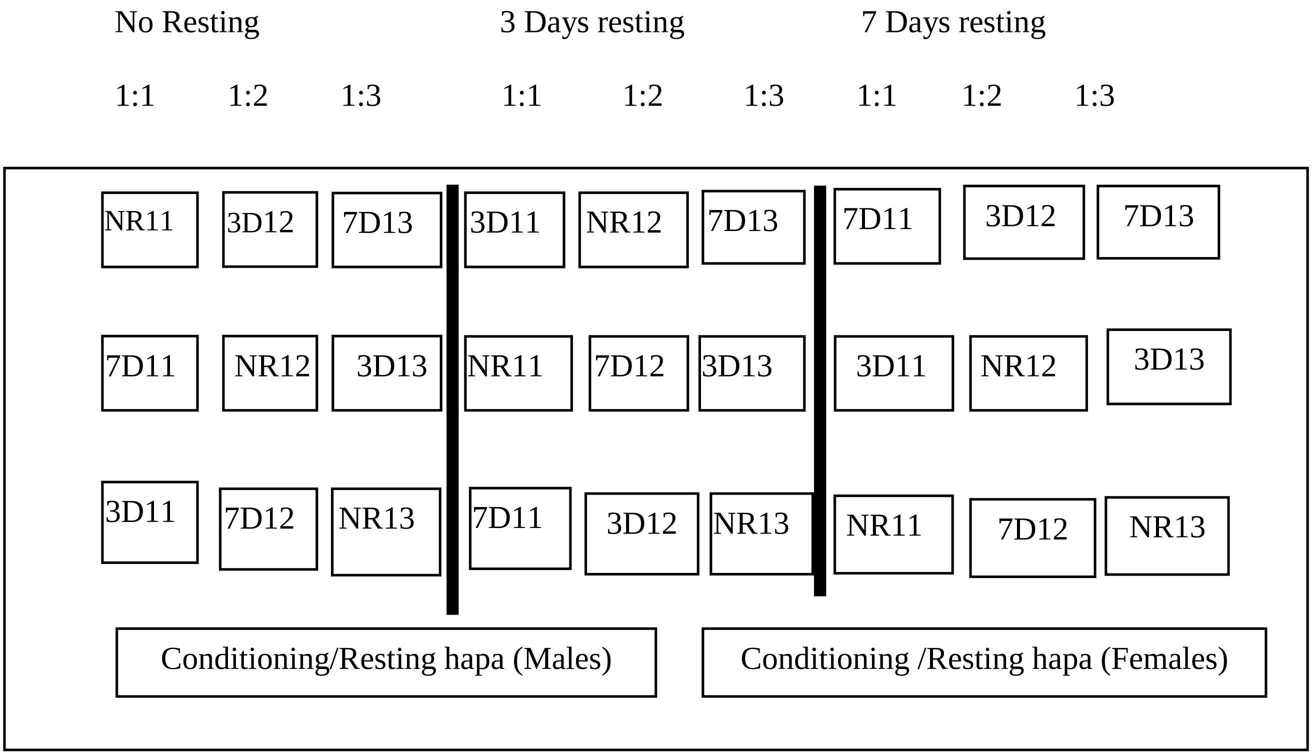

Figure 3.2: Experimental design

3.3 Nile tilapia conditioning and stocking

The brooders were selected, hand sexed into males and females and put into two (2) separate $6m^3$ (2m x 3m x 1m) hapas and fed with Coppens artificial pellet feed of diameter 4.5mm at 3% of BDW twice daily at 9:00 am in the morning and 4:00 pm in the afternoon for two weeks to condition them prior to the commencement of the experiment.

The brooder population was 54 females of an average weight (171±23.7 g) and 27 males (200±50 g).

After conditioning, the Nile tilapia brooders for the experiment were selected and weighed according to the desired sizes to eliminate bias, hand sexed and paired into twenty seven (27) (1mx1m x1m) hapas. The hapas were suspended to have a water depth of 0.6 m inside the hapa in a 1500 m^2 pond of depth 1.5 m. The hapas were supported with sticks and kept in position against the wind and current by using sand filled bottles as weights (Plate 2 & 3).

Male and female brooders were paired in the male to female ratios of 1:1, 1:2 1:3 with nine replicates each resting intervals of 0, 3 and 7 days. The brooders were fed for 14 days after which fry produced were harvested on the 14^{th} day as the control experiment for the pairing ratios. The brooders were then separated and rested for 0, 3 and 7 days respectively with the 0 or No rest being the control experiment for the resting periods. After resting, the brooders were re-paired in the male to female ratios of 1:1, 1:2 1:3 under the resting intervals of 0, 3 and 7 days for another 14 days for the next breeding cycle and fry harvest (main experiment).

Plate 3.2: The layout of the experimental hapas in the earthen pond.

Plate 3.2: View of a labelled experimental hapa

3.4 Feeding of Brooders

The brooders were fed twice daily (09hours and 16hours GMT) at 3% body weight with (Coppens, Holland) feed of particle size 4.5 mm at 37% crude protein level.

3.5 Water Quality Measurement

Water quality parameters such as temperature, dissolved oxygen, pH, and, salinity were taken from the hapas throughout the experiment with a multi parameter probe Horiba Water Quality meter U-51(Horiba Ltd., Kyoto, Japan). Water samples collected from the hapas were tested for ammonia and nitrite and nitrate concentrations on weekly basis.

3.6 Harvesting of Fry

Fry were harvested by untying and lifting one end of the hapa to concentrate brooders at the other end for scooping with hand nets before fry were finally collected (Plate 4). This prevented mortality of fry due to aggressive movement of the broodstock. The mouth of the female brooders were examined for naturally spawned eggs or yolksac fry. This was done for all the 3 treatments at 14 days inter harvesting interval. The fry were put in a basin of water, cleaned and counted using gravimetric estimation. The gravimetric estimation was done by weighing a spoonful of fry and multiplying it by the number of spoons of fry scooped to obtain the total number of fry produced in each treatment.

Plate 3.4: Collection of seed into basins

The following production parameters were estimated based on the mathematical relationships:

% Hatching = (No. of fry produced before resting brooders / No. of fry produced after resting brooders) x 100

Fulton's condition factor for brooders:

$K = W/L^3 \times 100$

Where K is the condition factor, W is the final weight and L is the final body length (cm).

(Froese, 2006)

Survival Rate (SR %) of brooders:

SR = N2/N1 x 100

Where N1 is the total number of stocked fish and N2 is the total number of fish surviving.

(Ridha, 2006)

3.7 Data Analysis

The data collected was subjected to one-way ANOVA to analyse the means and post hoc analysis using Duncan's multiple range test to test for significant differences ($p<0.05$) between the treatment means.

CHAPTER FOUR

4.0 RESULTS

4.1 Water Quality in hapas

Table 4.1 indicates the mean values of water quality parameters measured during the study in the breeding hapas. Mean water temperature ranged from 29.03±0.51°C at 9:00am in the morning to 34±0.5°C at 12:00noon in the afternoon. Dissolved oxygen (DO) concentration varied from 7.56±0.04 mg/L at 9:00am in the morning to 12.73±0.15 mg/L at 12:00am in the afternoon. The levels of ammonia, nitrite and nitrate obtained were 0.1±0.060, 04±0.3 and 0.17±0.05. The mean salinity level recorded was 0.25±0.01‰.

Table 4.1: Physico-chemical characteristics for breeding hapas at the Ashaiman Aquaculture Demonstration Centre during the study period.

	Mean values ± standard deviation		
Parameter	**Morning**	**Afternoon**	**Evening**
Temp (°C)	29.03±0.51	34±0.50	32±0.20
DO (mg/L)	7.56±0.04	12.73±0.15	10±0.50
pH	7.8 ±0.2	weekly	
Ammonia (mg/L)	0.1 ± 0.06	weekly	
Nitrate (mg/L)	0.17±0.05	weekly	
Nitrite (mg/L)	0.04±0.3	weekly	
Salinity (‰)	0.25±0.01‰	weekly	

4.2 Broodstock Growth Parameters

The brooders' parameters are presented in Table 4.2. No significant differences were found between the treatment groups in terms of fish size (weight and length) at the beginning of the experiment. The average weight of female brooders was 171 ± 23.7 g and that of the males was 229 ± 5.43 g. At the end of the experiment, mean weight for females was 184±22.4g and 266.5±20g for the males. The specific growth rate of the male and female brooders were (2.7±0.02g) and (2.68±0.08g) respectively. The condition factor of the male and female brooders were (3.46±0.34) and (3.42±0.24). The male brooders had a survival rate of (99%) and the female brooders (95%) at the end of the experiment.

Table 4.2: Production parameters of Nile tilapia brooders at the Ashaiman Aquaculture Demonstration Centre.

Parameters	Female	Male
Initial body weight (g)	171.6±21.7o	229.6±5.43
Final body weight (g)	184±22.4	266.5±20
Specific growth rate (%/day)	2.68±0.08	2.7±0.02
Initial condition factor (g/cm)	3.26±0.24	3.07±0.35
Final condition factor (g/cm)	3.42±0.24	3.46±0.34
% survival	95	99

4.3 Fry Production

The production parameters of the Nile tilapia fry is presented in Table 4.3. A total of 54 female brooders were used for this study. The estimated total number of eggs spawned by the females after being paired in the male to female ratio of 1:1, 1:2, 1:3 before rest (control experiment) was 21,703. The total number of fry harvested after resting the brooders for 0, 3 and 7 days was 6,584. The percent hatchability estimated to be 30.3% was obtained by comparing the number of fry produced under the different pairing ratios. The average number of fry per female is 122.

Table 4.3: Spawning parameters of the Nile tilapia brooders at the Ashaiman Aquaculture Demonstration Centre

Parameters	**Value**
Total no. of females	54
Average no. of fry / female	122
Expected total no. of fry	21,703
Estimated total no. of fry from all females	6,584
Percentage hatchablity (%)	30.3%

n=3

As showed in Table 4.4, the average fecundity (fry per female) for 7 Days resting period for 1:2 was the highest (1052) followed by 7 Days resting period 1:1 (947), 3 Days resting period 1:3 (703), NO rest 1:1 (501) and the lowest being 3 Days resting period 1:2 (391) and 3 Days resting period 1:1 (233). NO rest (1:2), NO rest (1:3) and 7 Days resting period (1:3) however recorded 0 seed output per female. The system productivity (total seed per female per m^2) values is the same as the total seed per female in a $1m^2$ hapa since all the treatment were done in $1m^2$ hapas.

Table 4. 4: Spawning efficiency of brooders in different pairing ratios and resting periods

	Broodstock pairing ratio					
Resting period	Mean number of fry produced			Fry produced/female		
(Days)	1:1	1:2	1:3	1:1	1:2	1:3
0	501±289	0	0	501	0	0
3	78±45	130±75	469±142	233	391	703
7	316±182	701±405	0	947	1052	0

4.4 Resting period and pairing ratio spawning performance

The total mean seed production for the control treatment (before rest) under pairing ratio 1:2 was the highest (969) followed by 1:3 (723) and (715) for 1:1 as shown in Fig 4.1. The highest total seed production observed for 1:2 was the highest (8760) followed by 6503 for 1:3 and 6440 for 1:1. The total seed production values recorded (after rest) had 7 Days rest 1:2 being the highest (2104) followed by No rest 1:1 (1503) and 3 Days rest 1:3 (1406). The lowest seed output was produced by 7 Days rest 1:1 (947) and 3 Days 1:2 (391) with the least being 3 Days 1:1 (233). There was no seed output for (Fig 4.2).

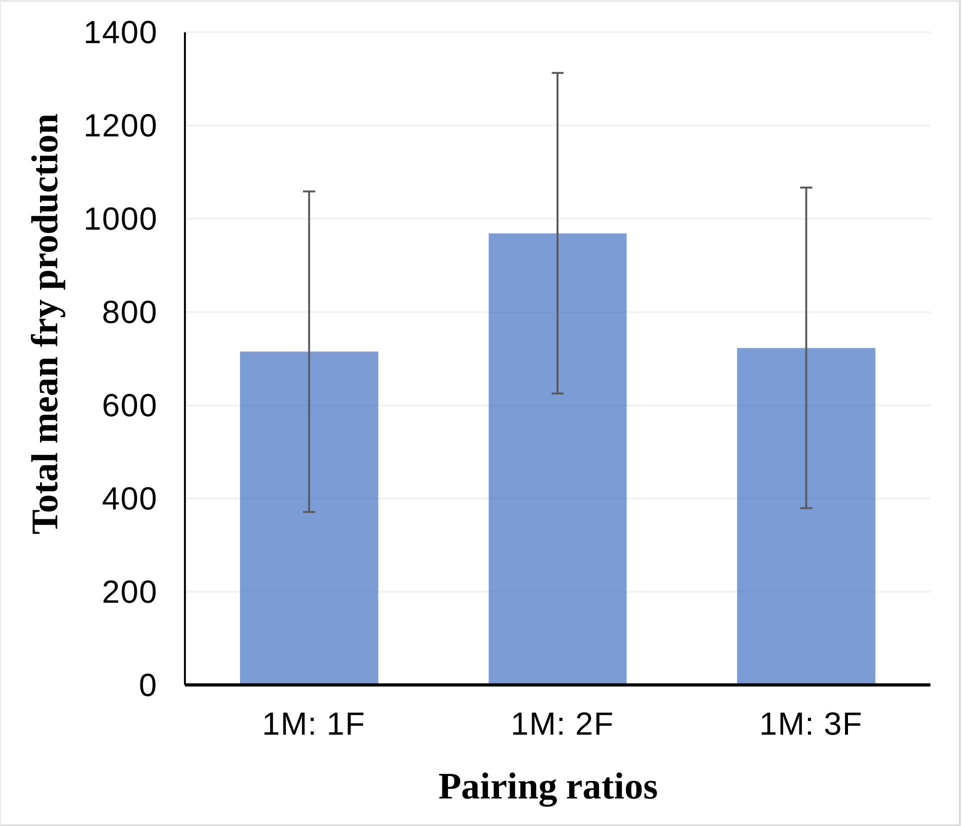

Figure 4.1: The effect of pairing ratios on fry production

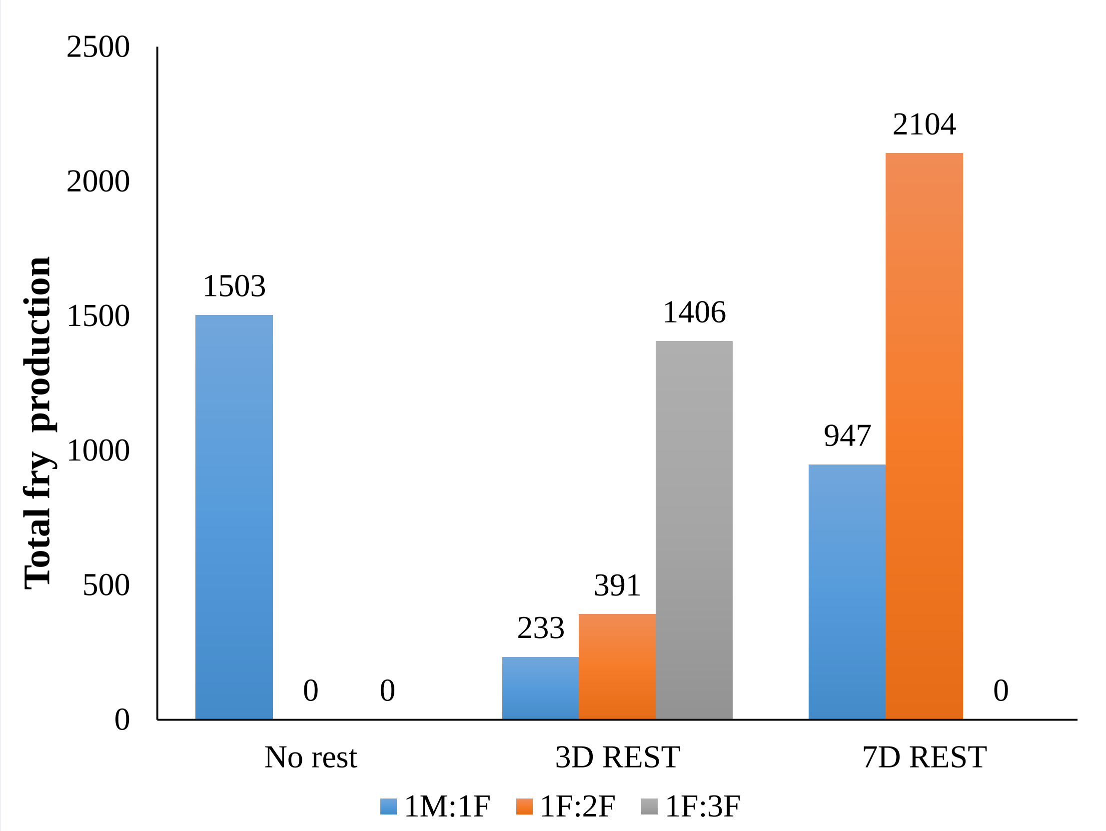

Figure 4.2: The effect of resting period on fry production

The spawning performance of Nile tilapia brooders under the different broodstock resting periods (Fig 4.3) indicates that 7 Days 1:2 pairing ratio produced the highest fry output (2104), followed by No rest 1:1 (1503), 3 Days 1:3 (1406). The least seed output was produced by 7 Days 1:1 (947) and 3 Days 1:1(233). No seed was produced for 7 Days 1:3, No rest 1:2 and No rest 1:3 pairing ratios respectively.

The mean seed produced for the control (before rest) and nine treatments (after rest) under the different pairing ratios and resting periods (No rest, 3 days, 7 Days for 1:1, 1:2 and 1:3 sex pairing ratios) are presented in Fig 4.4. The 1:2 brood stock pairing ratios at 7 days resting interval (7D12) gave the highest mean seed output of 701 followed by the 1:1 brood stock pairing ratio of no resting interval (NR11) with a mean seed output of 501. The 1:3 brood stock pairing ratios at 3 days resting interval (3D13) produced 469 as against 315 of the 1:1 at 7 days resting period (7D11). The least seed output of 130 were produced by the 1:2 brood stocking pairing ratios at 3 days resting interval (3D12) and a seed output of 116.5 by the 1:1 brood stock pairing ratios at 3 days resting period (3D11). The 1:3 brood stock pairing ratio at 7 days (7D13), 1:2 brood stock pairing ratios at no resting interval and 1:3 brood stock pairing ratios at no resting interval (NR13) recorded no seed output.

There were no significant differences (P>0.05) within and between means of seeds produced under the resting periods and pairing ratios.

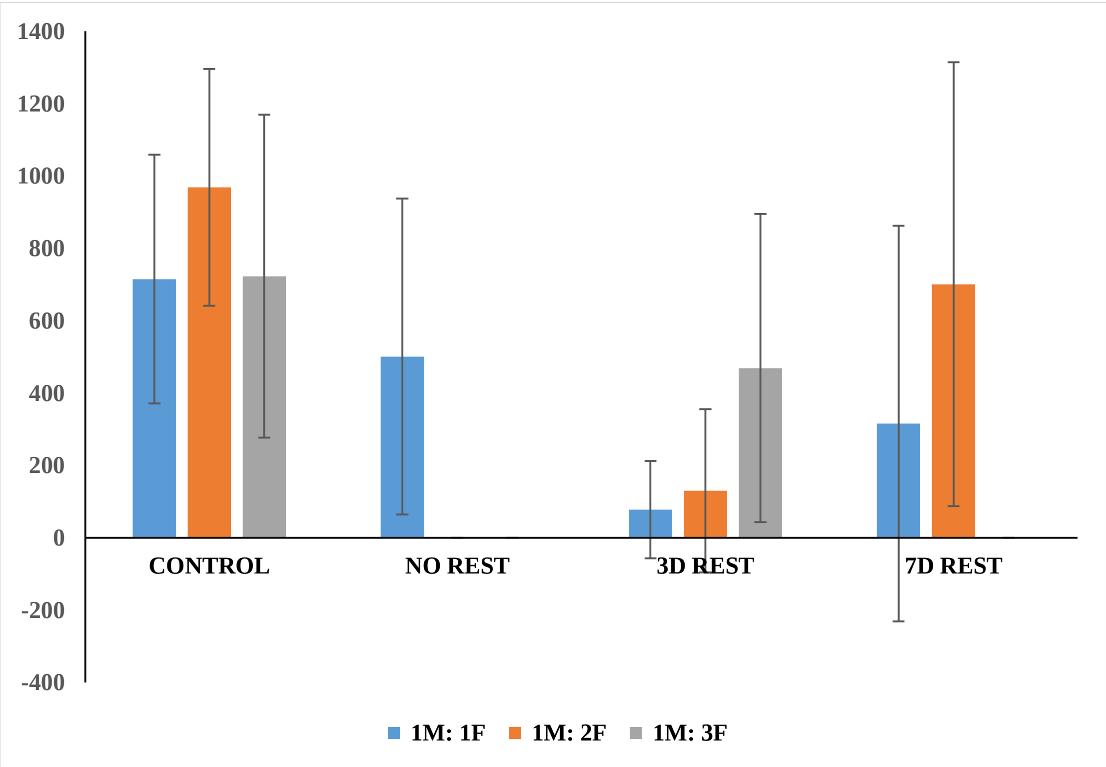

Figure 4.3: Pairing ratios, resting periods and their combined effect on fry production.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Water Quality Parameters

The levels of the water quality parameters obtained during this study were within the acceptable range for spawning and growth of the Nile tilapia as reported by Magid and Babiker, Ross (2000), El-Sayed (2006) and El-Sherif (2008).

The optimum temperature range suitable for reproduction and survival of Nile tilapia occurs at a temperature of 27°C to 30°C (Azaza *et al.*, 2008). The water temperature values (29-32°C) in this study were higher comparatively possibly because the experiment was conducted during the warmest season of the year (December-March, 2019), although it was also within the acceptable range for reproduction. According to Yadav (2006) reproductive performance has been found to be very poor at temperatures higher than 35°C and lower than 22°C. Rashid *et al.* (2013) also reported that egg production decreases with increased water temperature and this could probably account for the reduced fecundity/fry production as the study progressed into March (32°C) as against the start of the study which was conducted in January (29°C). Thus, the water temperature range (29-32°C) during this study was within the recommended tolerable range (22-35 °C) which is acceptable for breeding and fry production for the Nile tilapia.

The diurnal fluctuations in oxygen levels with supersaturation during the day and oxygen depletion at night are due to photosynthesis, respiration and diel fluctuations. The mean value of 7.56±0.04 mg/L obtained in the morning showed that oxygen levels dropped during the night to a range which could still support Nile tilapia growth and reproduction. According to Boyd (2010) low DO value recorded in the morning is due to bacterial activities which consume oxygen and the lack of photosynthesis during the night to introduce or add on oxygen. The lowest limit of the dissolved oxygen for optimum fish production in ponds has been suggested to be 5 mg/l (Das, 2000, 2001) as cited by Choudhary and Sharma (2018)

El-Sayed (2006) reported that optimum growth of fish occurs at pH ranges between 7.5 and 8.5 whiles Bardach *et al.* (1972), Guerrero (1997), Popma and Masser (1999), Nandlal and Pickering (2004), and Peterman (2011) reported acceptable range of pH from 6 to 9. As indicated by Choudhary and Sharma (2018), tilapia generally can survive in pH ranging from 5 to 10 but do best in pH range of 6 to 9. This confirms that the mean level measured during the study (7.8 ±0.2) is acceptable and suitable for reproduction and spawning.

According to Nadlal and Pickering (2004), suitable salinity levels for Nile tilapia culture in fresh water medium could rise from 5 to 10‰. Fineman-Kalio (1988) and El-Sayed *et al.* (2003) indicated that gonadal development and spawning of Nile tilapia could occur at salinities as high as 17-29‰ but stops completely at salinity above 30‰. The mean salinity (0.25±0.01‰) obtained from this work was acceptable and suitable for reproduction.

5.2 Broodstock Growth

The mean specific growth rate of the male brooders (2.7±0.02 %day^{-1}) was slightly higher than the females (2.68±0.075) because the female brooders channelled their energy to egg/fry production instead of somatic growth (Olurin *et. al.*, 2006). This probably accounted for the slightly lower mean condition factor of the female brooders (3.42±0.24) after the breeding cycle relative to the condition factor of the males (3.46±0.34). The male brooders had a higher survival rate (99%) than the female brooders (95%) possibly due to reproductive fatigue as maternal mouth brooders.

5.3 Fry Production Performance

The lower spawning numbers (6,584) observed in the two resting periods (3 and 7 days) compared with the numbers recorded at the start of the experiment (21,703) was probably caused by exhaustion of the broodstock (Ridha and Cruz (1998); Ridha *et al.* (1998) from continuous use of the same broodfish prior to the commencement of the study since fresh and naïve/unused broodstock could not be obtained for the study. The separation, resting and re-pairing of broodstock for subsequent experimentation after the initial/control phase led to interruption in social interaction during the two weeks conditioning period. Little *et al.* (1993) and Ridha & Cruz (2000) noted that interruption of social interaction could affect fry production performance of brooders. Cannibalism and incomplete harvest could not be ruled out as possible contributors to mortalities and the concomitant low fry production (Bhujel *et al.*, 2000).

Reproductive performance, as indicated by larvae output per female/hapa was enhanced in experimental units where broodstock were rested. The mean larvae production for females rested for 3 and 7 days increased by 35% and 103% respectively as compared to the zero rest systems, indicating that resting possibly replenished/renewed the spent energy of the fish from earlier spawning occurrence.

Pairing broodstock at lower ratios of 1:1 at the commencement of the study and 1:2 with 7-day resting period produced more fry than stocking at a higher ratio of 1:3 with or without rest. This indicates better performance of male brooders with fewer females than higher sex ratios or density. This may be due to the single male's ability to consistently interact with each female to trigger breeding. The higher fry production of 501 in the 0 Rest at a ratio of 1:1 could have resulted from the male consistently pressuring the female to breed without any competition from other males in the 1 m^3 hapa. The low density may also have enabled the female to establish a "safe territory" in which to reproduce consistently but the quality of fry produced could be compromised due to the low reproductive strength of the male from continuous breeding. Therefore, to maximize fry production per female without resting in a brooding system, a pairing sex ratio of 1:1 should not be exceeded.

The poor fry output at the highest pairing ratio and longest resting period could be due to higher stocking density of 4 fish/m^2 coupled with a prolonged resting period. At higher densities there is competition for space which eventually affects reproductive efficiency whilst ovulation and reabsorption of eggs may also occur during long period of rest. According to Peters (1983) the reabsorption of well-developed ova in the ovary is related to the lack of opportunity to spawn due to a higher resting period.

On the other hand, higher resting period with a lower stocking density (3 fish/m^2) appeared more favourable, probably due to increased mating frequency. Lovshin and Ibrahim (1988) found a 16% increase in egg and fry production over a 105-day period by resting *O. niloticus* males and females every 21 days. This may be due to the active roles of rested males in courtship and restored vitality of females to produce more quantity and quality of eggs (Lovshin and Ibrahim, 1988).

Glenny (2002) suggested that the breeding process be terminated once a peak production period of 17 to 20 days after stocking had been reached, and that these breeders be replaced. The low condition factor of females in the 1:2 and the 1:3 ratios with no rest paid credence to the zero fry output from these systems. The continuous breeding under a higher stocking density reduced the reproductive strength of the males and the regenerative capacity of the females to produce eggs.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The quality of water used at the Centre for the production of Nile tilapia fry were within acceptable limits for breeding and fry production of this cultured fish species.

A broodstock sex pairing ratio of 1:2 combined with a resting period of 7 days after each successful spawning cycle was the best option for the management of the current Nile tilapia broodstock used at the Ashaiman Aquaculture Demonstration Centre for fry production.

Fry production for brooders rested for 3 and 7 days increased by 35% and 103% from values obtained from brooders that were not rested irrespective of their sex pairing ratios.

The broodstock management practice of not resting the brooders is inimical to improved Nile tilapia fry production as indicated by the result from the study.

6.2 Recommendations

- A repeat of this study with unused/naive broodstock should be carried out to further ascertain the effects of the combined ratios and resting periods on Nile tilapia fry production.
- The study should be carried out over a longer duration to grow the fry to the fingerling stage to determine their viability and hardiness for grow-out operations.
- The findings of this research should be presented orally to the management of the Ashaiman Aquaculture Demonstration Centre of the Fisheries Commission

where the brooders are used without rest for improved performance of fry production.

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APPENDIX

Appendix 1: Single factor ANOVA showing the significant differences between and within means of fry produced under the different sex pairing ratios and resting periods

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1650026.074	8	206253.259	1.661	.176
Within Groups	2234709.333	18	124150.519		
Total	3884735.407	26			

	N	Mean	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
				Lower Bound	Upper Bound		
NO RESTING 1:1	3	501.00	252.258	-584.38	1586.38	0	803
NO RESTING 1:2	3	.00	.000	.00	.00	0	0
NO RESTING 1:3	3	.00	.000	.00	.00	0	0
3 DAYS 1:1	3	77.67	77.667	-256.51	411.84	0	233
3 DAYS 1:2	3	130.33	130.333	-430.45	691.11	0	391
3 DAYS 1:3	3	468.67	246.060	-590.04	1527.38	0	833
7 DAYS 1:1	3	315.67	315.667	-1042.54	1673.87	0	947
7 DAYS 1:2	3	701.33	354.411	-823.58	2226.24	0	1141
7 DAYS 1:3	3	.00	.000	.00	.00	0	0
Total	27	243.85	74.390	90.94	396.76	0	1141