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Breeding of Common Carp (*Cyprinus carpio*) using Different Approaches

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Thirty-three broodstock of common carp (*Cyprinus carpio*) obtained from Panyam Fish Farm, plateau state Nigeria was used to evaluate the percentage hatchability of carp through induced natural spawning in outdoor Hapa net system, and induced breeding by stripping in indoor concrete Ponds. Spawning and fertilization was natural for experimental group 1. Ovaprim hormone was used to induce broodstock in experimental group 2 and 3, but unlike experimental group 3, experimental group 2 was not stripped manually, as the induced female broodstock shed her eggs naturally. At the end of the experiment, the mean number of eggs in one gram was found to be (733.33 ± 3.53^{a}) in treatment 3, as compared to that of experimental group 2 (702.00 ± 3.21^{b}) and experimental group 1 (709.33 ± 4.91^{b}), with a significant difference at ($P<0.05$). There was no significant difference ($P<0.05$) in fecundity ($x10^{3}$) from the three experimental groups. Percentage fertilization was highest in experimental group 2 (94.44 ± 0.40^{a}). Percentage Hatchability was highest in experimental group 3 (94.10 ± 0.85^{a}). Number of post fry in one liter of water at day seven after hatching was found to be highest in experimental group 3 (1896.30 ± 53.40^{a}). In conclusion, the best method of carp propagation for aquaculture is the synchronized propagation through stripping in indoor concrete ponds, which had 94% hatching rate.

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1. INTRODUCTION

Annually, almost 100 million tons of fish are captured from the ocean, of which around 70 million tons are intended for direct human consumption. This amount includes hundreds of species. Some of these,are predatory species, that are threatened with extinction [1,2]. Thus, the growing demand for fish and fish products for human consumption must be covered by fish farming through aquaculture practice.

Worldwide, the most important cultured fish species used in fish farming are, in order common carp, salmon, tilapia, and catfish [3]. Hence, deliberate measures in aquaculture must be taken towards the sustenance of these important fish species.

According to Ifkhar and Iftkhar [4], Carp naturally spawn in the spring and early summer depending upon the climate of the area. They separate into groups in the shallow areas to spawn. Carp prefer shallow waters with dense macrophyte cover, an environment where they can comfortably shed their eggs and milt and successfully hatch their offspring's. Males spill their milt and fertilize the eggs, which the females scatter over macrophytes in a very active manner. The eggs get attached to the substrates upon which they are scattered. Generally, a typical female (about 45 cm) can produce up to 300,000 eggs, with some estimates as high as 1, 000, 000 over a breeding season.

Naturally, the reproduction of carp depends on three main groups of factors. These are the basic factors of Temperature (18 - 24 C), dissolved dxygen (5 - 10 mg/liter), and light. Furthermore, are the stimulating factors which includes favorably changing atmospheric pressure, the presence of males and a suitable vegetation to spawn on.

All propagation methods for fish culture are based on the reproductive biology of fish. These methods (varying with species of fish) are an imitation of favorable spawning conditions, general interference in the neurohormonal control of its reproduction. This involves controlled spawning, induced spawning, induced ovulation, and their combinations, which can be distinguished accordingly. The methods for common carp propagation are summarized into three approaches which are natural propagation, semi- artificial and artificial methods.

In the natural-like propagation, only basic environmental conditions are ensured. Ponds with fleshy flooded grassy areas can be used for natural-like propagation of carp. Mature broodstock are stocked at about 3-4 females per hectare, and 2-3 males per female, and those of them that have engaged will spawn naturally. This means that there is no artificial or manual inducement whatsoever on the broodstock as injection or stripping activities will be carried out by the farmer or hatchery operator. However, environmental conditions must be kept at favorable ranges, for successful spawning.

Semi-Artificial method of propagating common carp can be using Synchronized spawning in grassy ponds. This method includes 'The Dubisch Method', synchronized spawning in breeding Hapas or synchronized Spawning on Kakabans. The Dubisch method of common carp propagation is possible through ensuring of suitable essential environmental conditions. Small floodplain-like ponds (100-1000m^2) are most suitable for this kind of propagation method, where the breeders or broodstock can be introduced after inducing them with hormone, for breeding activities to be carried out. Spawning will take place by one or two sets of breeders (2 females and 3 males per set) stocked in pond. The imitation of flooding induces spawning. After the spawning, breeders are scooped out of the pond using Scoop net to leave eggs and larvae in water, such that developing eggs and larvae can easily be observed.

Artificial propagation of fish in general and of common carp specifically is when propagation is fully programmed, and each phase is completed under controlled hatchery conditions strictly. Key steps of artificial propagation viz - First, the injection of suitable broodstock with gonadotropic hormones, which will be done twice for the female fish and once for the male fish. This is followed by stripping of its sexual products (eggs and sperm), usually done 10-12 hours after injection (depending on the temperature of the water). Thereafter, fertilized eggs should be treated against stickiness and then incubated in hatchery jars or small receptacles. Hatched larvae are placed and reared in large jars, and as soon as larvae grows and starts to feed, they can now be stocked into nursery ponds. This study is

an attempt to identify the most efficient reproduction practice of carp to ensure optimum aquaculture practice of the species, thereby salvaging it from its current threatened state of extinction. Thus, this study was designed to evaluate the percentage hatchability of carp through natural breeding using outdoor hapa, to evaluate the percentage hatchability of carp using induced natural spawning system in outdoor hapa, and to evaluate the percentage hatchability of carp by artificial propagation through induced breeding by stripping in indoor concrete tanks.

2. MATERIALS AND METHODS

2.1 Study Area

This experiment was conducted in Panyam Fish Farm, Panyam, Mangu Local Government Area of Plateau State, Nigeria. Panyam Fish Farm is situated in Mangu, around 60 kilometers South-East of Jos. The physico-chemical parameters of experimental water were taken three times in a day at 7am, 12noon and 6pm respectively, using relevant instruments and was observed to be within tolerable range for Carp culture as descried by Bert [5], Billard [6], and [7].

2.2 Fish Specimens

A total of 50 fish specimens (25 male and 25 female) were obtained from Panyam Fish Farm and were isolated in separate Hapa net of 3m by 7m by 1.5m dimension each and fed intensively with 9mm size of Vital feed extruded floating pellets, for 3 months, before they were certified ready for spawning. 33 broodstock (12 females and 21 males) were selected out of the 50 isolated fish specimens and used for this experiment.

Selecting the broodstock was done after a period of screening for readiness to spawn by putting little pressure on the abdominal regions towards the genital area of each broodstock, to check for quality of milt and eggs respectively.

2.3 Experimental Group 1

2.3.1 Evaluation of percentage hatchability of carp through uninduced natural spawning

Selected *Cyprinus carpio* fish was grouped three males to one female, per Hapa, weighed, and enclosed in Hapa nets with grasses. A total of three female and nine male broodstock were used. No hormone was administered. Water temperature was observed to be maintained at 19°C -22°C, at a saturated dissolved oxygen level of 7.45Mg/L – 9.05Mg/L, with water level increasing slowly from inlet. The paired broodstock were kept in Hapa net (3m*1.5m*1m) and volume of water was increased gradually to mimic flooding that can trigger egg release. After egg released and fertilization took place, the spawners were netted out of the Hapa for incubation process to continue.

Fertilization was done by the activities of spawners, kept together in the already prepared net with Kakabans, where the male released milt on the eggs shed by the female spawners. This took place in 3 double Hapa net of sizes 3m×1.0m× l.5m dimension of 0.5 mesh size with inner lining of netting material (1.0 mesh size) each of same dimensions, with three replicates and Kakabans respectively.

To determine fertilization rate, one gram of egg mass which was not inseminated was used. The time taken for the control eggs to become blurred (dead) was noted and the clear appearing eggs in the incubation tanks was counted and termed the fertilized eggs. This method was described by Ella [8] as:

Percentage Fertilization= (N-b) x 100

Where N represents the sample of spawned eggs, b represents number of bad eggs.

2.4 Experimental Group 2

2.4.1 Evaluation of percentage hatchability of carp by through induced natural spawning

Selected fish were grouped into male and female and weighed. Upon weighing, a dosage of 0.8ml of hormone per kilogram of the stocks body weight (for female), and 0.3ml per body weight for male each of ovaprim hormone was administered to the broodstock, at the pectoral fin and above the lateral line at an angle of 45° after the head region. A first dose of 20% of 0.8ml ovaprim per kg of the stocks body weight was given to the female fish. This was given at 10am of the first day, followed by a second dose of 80% of 0.8ml ovaprim per kg of the stocks body weight, given to the female after 12 hours (10pm) of the same first day to get the eggs ready for stripping. However, the male was

administered with a single dose of 100% of 0.3ml per body weight just at the same time interval the second dose was being given to the female broodstock. The first dose was administered at10am and the second dose at 10pm to get the eggs ready for stripping.

With the Hapa net well prepared and immersed in pond, stocked with newly filled grasses. Spawning took place at about 72 hours from time of the first dose administration i.e., at about 10am on the third day.

Broodstock was induced and allowed to spawn naturally. The female stock shed her eggs on the second day after about 13 hours (11am in the second day) from the 10pm of the first day (after the second dose was given by 10pm of the first day), and pairing began with the display of the courtship behavior between the male and female spawners.

Immediately after spawning, the broodstock were removed from the net, to leave room for fry to hatch in the Hapa. This they did on the third day at about 73 hours from the first dosage injection time.

To determine percentage fertilization, 1gram of egg was obtained from the female by stripping after it was removed from the Hapa. The gently stripped eggs were degummed by the application of 10% formalin.

To determine fertilization rate, the 1gram of egg mass which was not inseminated was used to determine fertilization. The time taken for the control egg to become blurred (dead) was noted at 1hour timing, and the clear appearing eggs in the incubation tanks was termed the fertilized eggs, as described by Ella [8], using percentage fertilization.

Degumming of eggs was done using 10% formalin. The solution was poured on the 1 gram of eggs to make them distinctly separable and make ease for counting.

Number of eggs per gram was determined using an Electronic/digital weighing balance(model HR-100A/100AZ, China) and counting was done on a glass slide slab in a Petri dish.

Incubation was carried out in the same 3 double Hapa net of dimensions 3m× lm×1.5m with finer mesh size 0.5mm net lining each, with three replicates and Kakabans respectively.

Eggs were monitored for 73 hours till hatching was successfully recorded. Incubation was done in Hapa nets.

2.5 Experimental Group 3

2.5.1 Evaluation of percentage hatchability of carp through induced breeding by stripping in indoor concrete ponds

Selected fish was grouped into male and female and weighed. Upon weighing, ovaprim hormone was administered, at the pectoral fin and above the lateral line after the head region. This administration was done twice.

First, an initial dosage of 20% of 0.8ml ovaprim per kg of the stocks body weight was given to the female fish, followed by a second dose of 80% of 0.8ml ovaprim per kg of the stocks body weight, given to the female after 12 hours (10pm) of the same first day to get the eggs ready for stripping. For male, only a single dose of 100% of 0.3ml per body weight of fish was given to the male fish, just at the same time interval the second dose was being given to the female broodstock the male.

With concrete tanks and environment, stocked with newly filled grasses and well-conditioned, hatching took place in day three from first injection time.

Stripping in indoor concrete tanks was done manually by hand after a period 73 hours from the first dose. Stripping was by mild pressure application to let out milt and egg content from both spawners, after which a gram of eggs was scooped out for further evaluation process.

Degumming of eggs was done using 10% formalin. The solution was poured on the 1 gram of eggs to make them distinctly separable and make ease for counting.

Number of eggs per gram using an electronic/digital weighing balance were determined and counting was done on a glass slide slab in a petri dish, and a spatula used to isolate and count eggs to determine number of eggs per gram.

The fertilization rate was determined according to Ella [8] one gram of egg mass which was not inseminated was used to determine fertilization. The time taken for the control eggs to become blurred (dead) was noted at 1hour, and the clear

appearing eggs in the incubation tanks termed the fertilized eggs.

Incubation was done in the concrete tanks, with close supervision of artificial fertilization, removal of stickiness and hatching. Fry was nursed in same concrete tanks and other observations made.

2.6 Data Analysis

The analysis was carried out using Excel Stat and Minitab 14 to highlight the possible heterogeneity between the populations.

3. RESULTS

The result of number of eggs in one gram, fecundity, percentage hatchability, and number of fry in one liter of water, of the fry to post fry progenies of the crosses of the three different experiments on hatching carp through uninduced natural spawning, induced natural spawning, and induced spawning by stripping are shown in Table 1.

The number of eggs in one gram was found to be highest (733.33±3.53^{a}) in the broodstock from the purely artificial propagation (induced spawning by stripping) setting, as compared to that of semi-artificial or induced natural spawning (702.00±3.21^{b}) and completely natural (uninduced) spawning setting (709.33±4.91^{b}) propagation with a significant difference at (P<0.05).

Total number of eggs shed was determined in line with the number of eggs in a gram to be 112566.16 in the broodstock from the purely artificial propagation (induced spawning by stripping) setting, as compared to that of induced natural spawning (102498.19) and completely natural (uninduced) spawning (709.33±4.91^{b}).

The higher fecundity (x10^{3}) was found in the natural propagation (107.85±15.50), as compared to induced natural spawning (102.01±18.48) and purely artificial i.e., induced spawning by stripping method (98.81±4.02) with no significant difference at (P<0.05).

Table 1. Water quality parameters for panyam fish farm pond water

Parameters	Time			
	7 am	12 noon	6 pm	Mean
Temperature (^{o}C)	20.40±0.32	22.23±0.32	19.93±0.1	20.86±0.25
pH	7.48±0.05	7.60±0.11	7.55±0.08	7.54±0.05
Dissolved Oxygen (mg/L)	8.13±0.19	8.73±0.13	8.20±0.09	8.35±0.09
Total Dissolved Solids (mg/L)	133.67±2.84	140.77±2.58	135.88±2.22	136.77±1.54
Electrical Conductivity (µS/Cm)	237.21±2.90	240.18±3.55	230.28±1.65	235.89±1.78
Transparency (Cm)	42.33±0.64	57.13±0.68	42.37±0.64	47.28±1.49

Table 2. Hatching parameters of carp using three different breeding systems

Parameters	Rearing Systems			P-Value
	Un-Induced Natural Spawning (T1)	Induced Natural Spawning (T2)	Induced breeding by stripping (T3)	
Weight of fish (g)	993.30±23.30	996.70±12.00	976.70±17.60	-
Weight of Eggs (g)	144.50±21.50	143.50±25.00	153.50±21.50	<0.01
No. of eggs in 1g	702.00±3.21^{c}	709.33±4.91^{b}	733.33±3.53^{a}	<0.01
Total No of Eggs	100737.00	102498.19	112566.16	
Fecundity (X 10^3)	107.85±15.50	102.01±18.48	98.81±4.02	0.36^{ns}
Percentage Fertilization	73.12±0.30^{c}	94.44±0.40^{a}	89.86±0.10^{b}	<0.01
No. of Post Fry per 1L of water	838.00±75.20^{c}	1572.36 ±52.00^{b}	1896.33±53.40^{a}	<0.01
Percentage Hatchability	37.54±0.20^{c}	72.73±0.93^{b}	94.10±0.85^{a}	<0.01

Means on the row with different superscript are statistically significant (p<0.05). ns=not significant

Percentage fertilization was found to be highest in sample collected from the experimental group of the induced natural spawning (94.44±0.40[a]) as compared to Induced spawning by stripping (89.86±0.10[b]) and uninduced natural spawning using outdoor Hapa net (73.12±0.30[c]).

Percentage Hatchability was found to be highest in sample collected from the experimental group of induced spawning by stripping in indoor concrete tank system (94.10±0.85[a]) as compared to induced natural spawning (72.73±0.93[b]) and natural (uninduced) propagation using outdoor Hapa net (37.54±0.20[c]).

Number of post fry in one liter of water at day seven was found to be highest in sample collected from the experimental group of artificial propagation i.e., induced spawning by stripping in indoor concrete tank system (1896.30±53.40[a]) as compared to induced natural stripping (1572.30±52.00[b]) and completely natural propagation using outdoor Hapa net (843.00±75.20[c]).

4. DISCUSSION

The number of eggs in one gram and total number of eggs generally was found to be highest (733.33±3.53[a]) in the broodstock from the purely artificial propagation setting (induced stripping), as compared to that of induced natural spawning or semi-artificial (709.33±4.91[b]) and completely natural setting or uninduced natural propagation (702.00±3.21[c]) with a significant difference at (P<0.05). The significant difference here could be because of the application of ovaprim hormone and the opportunity for complete stripping of the gravid broodstock. ovaprim hormone is used commonly for inducing breeding on finfish artificially because it has a salmon gonadotropin-releasing hormone equivalent and a dopamine antagonist, this hormone is very effective for finfish species [9,10]. Also, according to [11], a high-quality seed production demands a particular nutrition of broodstock which significantly affects fecundity and survival. From this study, all the broodstocks used were matured and healthy. They were isolated and given intensive care and intensive feeding for a period of three months. High quality and ration of feed was fed the broodstock to satiation. Consequently, if fecundity were based on feeding alone, the three different experimental groups would have had no significant difference with number of eggs per gram. Also, another discussable reason for the statistical difference could be based on age of fish, genetic and inherent factors peculiar to the broodstock used by the respective experimental groups. However, during selection, brood fish used were seemingly of equivalent size, age, and weight. As reported by Parameswaran *et. al.,* [12], common carp is found to attain maturity when six to eight months old, the males about two months earlier than the females and at a smaller size, suggesting that the gene or age of the broodfish may not have been the sole cause of the significant difference. Hence, this could be due to hormone administration, and the complete stripping of eggs from the egg sac of the induced gravid female broodstock in the artificial breeding of experimental group.

The higher fecundity ($x10^3$) was found in the natural propagation using Hapa Net (107.85±15.50), as compared to induced natural spawning (semi-artificial) (102.01±18.48) and purely artificial or induced stripping (98.81±4.02), but with no significant difference at (P<0.05). Though the difference was not significant, the greater number attained in the natural propagation system could be attributed to the lower stress on the broodstock, associated with the natural propagation system as compared to the semi-artificial and completely artificial propagation systems. This implies that the gravidity of all the broodstock used for the different experimental groups was intact, relative to their body weight.

Percentage fertilization was found to be highest in sample collected from the experimental group of the induced natural spawning (94.44±0.40[a]) as compared to Induced spawning by stripping (89.86±0.10[b]) and uninduced natural spawning using outdoor Hapa net (73.12±0.30[c]) with a significant difference at (P<0.05). Possibly, the percentage of fertilization which was higher in experimental group two (induced natural spawning of 94%), could also be because of the less stress on the brood stock which was already to shed eggs after hypophysation (inducement from action of ovaprim on sex gametes). For fertilization to have occurred, milt from the male mixed with the eggs from the female. The union between the sex cells from both parents must have been without stress from handling on both broodstock as compared to the manual stripping of fish eggs and milt. Stress on broodstock affects reproduction potentials. Though the completely natural (uninduced natural spawning) too was without handler's stress on the broodstock used, it is imperative that its lowest

output could have been from the fact that the completely natural process of spawning may not have had a 100% conducive breeding environment, which could draw attention to the fish being in a confined area or in captivity in the Hapa net, thereby depriving the sex cells of broodstock from optimum development.

73% fertilization yielded 37% hatchability in experimental group one. 94% fertilization yielded 72% hatching success in experimental group two, and 89% fertilization yielded 94% hatching success in experimental group three. Observation shows however that the experimental group of the induced spawning by stripping did better than all other. Ordinarily, percentage fertilization should be commensurate to, or be a direct pointer to percentage hatchability. But in this experiment, the experimental group with the highest percentage fertilization did not yield the highest percentage hatchability.

The Percentage Hatchability was found to be highest with a significant difference at ($P<0.05$) in sample collected from the experimental group of artificial propagation through stripping in indoor concrete tank system (94.10 ± 0.85^{a}) as compared to induced natural spawning through stripping in outdoor Hapa net system (72.73 ± 0.93^{b}) and natural propagation using outdoor Hapa net (37.54 ± 0.20^{c}).

According to Montchowui et. al*.,* [13], the knowledge of artificial breeding is a key aspect as it permits intensive production of a given species in controlled conditions. This allows continued production of juveniles for restocking natural or artificial water bodies. This justifies the result obtained here, as the two experimental groups that were administered the ovaprim hormone had more hatching success, with other factors like water physico-chemical parameters same for every experimental group. Also, reproduction of carp is most often performed in hatcheries. After hatching, the larvae are transferred to small shallow pools or ponds with water rich in plankton, a sufficient food for the young individual carps [14].

The number of post fry in one liter of water at day seven was found to be highest in the sample collected from the experimental group of artificial propagation through stripping in indoor concrete tank system (1896.30 ± 53.40^{a}) as compared to semi-artificial propagation through stripping in outdoor Hapa net system (1572.30 ± 52.00^{b}) and natural propagation using outdoor Hapa net (843.00 ± 75.20^{c}). Considering the fact that there was no significant difference at ($P<0.05$) in the fecundity of all experimental groups, and the fact that the Hapa net used for the experiment was double netted (to avoid escape of fry into the water body, with the external layer of the netting of a smaller mesh size than the internal netting that housed the broodstock in the natural and semi-artificial experimental groups), the significant difference in the number of post fry in one liter of water at day seven after hatching could be obviously due to the complete stripping of the gravid and injected broodstock. It means that despite the conducive environmental conditions for the hatching of fry in all the experimental groups, the experimental groups without stripping may have obviously had some eggs left in the belly of the gravid female, ready for reabsorption. It also indicates that the use of Hapa nets may have conditioned the broodstock to a limited space for movement, which could be a source of stress to the fish. Furthermore, the application of synthetic hormone is relevant to the total ripening of the eggs embedded in the broodstock, ready for fertilization, hence the significant difference.

Generally, common carp breeds in natural water bodies. However, artificial breeding in commercial farm level is much more important for the successful expansion of aquaculture and farmers economic condition [15].

It was observed during this study, and during the different and repeated experiments carried out in various farm settings (with different atmospheric and water physico-chemical parameters of water), that common carp is a highly sensitive nontolerant fish species, and not as hardy or tolerant as other common culturable species of fish like African sharptooth catfish (*Clarias gariepinus)* as we have commonly available in Nigeria*,* unlike it was described by Sultana et. al*.,* [16] to have a hardy nature and described by Mills et al*.,* [17] to have a high tolerance to changeable environmental conditions. The experiences gathered from these processes suggests the need for a highly professional and skilled handling of fish species, in addition to ensuring the right culture medium to achieve spawning and culturing success.

5. CONCLUSION

From the result obtained, the best method of carp propagation for aquaculture is the induced

spawning by stripping in indoor concrete tanks, which had 94% hatching rate as compared to 72% from induced natural spawning and 37% from uninduced natural spawning.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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