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# Effect of monthly variation in water temperature on artificial breeding of common carp (*Cyprinus carpio* L.) in Zaria, Nigeria

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**Abstract**
The effect of monthly variation in water temperature on artificial breeding of common carp, *Cyprinus carpio* using ovaprim as an ovulation stimulator was studied. A total of eighteen (18) common carp broodstock were divided into three (3) groups. Each group had three (3) males and three (3) females, they were induced with ovaprim in three different months viz; January, February and March with corresponding water temperature of 23±1, 26±1 and 29±1 °C respectively. The result revealed that latency period decreases with increase in temperature, at 23±1 °C latency was found to be 16.55±0.13 hrs, at 26±1 and 29±1 °C latency was 13.00±0.13 and 11.32±0.07 hrs respectively. Temperature has a significant effect ($p \leq 0.05$) on fertilization and hatchability. *C. carpio* performed best in terms of fertilization (89.00±3.00%) and hatchability (67.50±2.50%) at the temperature of 26±1 °C. Increase in temperature leads to decrease in the hatching duration of *C. carpio* eggs, hatching duration was found to be 41.96±0:42 hrs at the temperature of 23±1 °C, at 26±1 °C hatching duration was 37.18±0:04 hrs and 28.98±0.96 hrs at 29±1 °C. It is therefore recommended that the temperature of 26±1 °C be used during artificial breeding of *C. carpio* in Nigeria.

**Keywords:** Fertilization, hatchability, latency, ovaprim, temperature

## 1. Introduction
Artificial breeding is an important procedure to replace declining fish stock and artificial reproduction of fish species in captive condition depends largely on environmental conditions, type of hormone used and its potency, dose of hormone and maturity status of the fish [1]. The success of induced breeding also depends on the latency period, appropriate combinations of inducing agents and stripping time always yield maximum egg output during induced breeding while improper coordination between these two will lead to breeding failure [2, 3].
Fish reproduction is regulated by some environmental factors which stimulates internal mechanisms into action; the final product of the reproductive cycle is the release of eggs and sperm, which can be controlled by either placing fish in an appropriate environment or by stimulating the fishes internal regulating factors with hormones or other stimulants [4].
Temperature is one of the most decisive environmental variables affecting the maturation and embryonic development of fish eggs. Hence, determination of the optimal temperature for common carp broodstock conditioning after inducement with hormone and egg incubation is necessary to maximize the fish seed production. In addition temperature determines the development of certain morphological features, hatching rate and the larval behaviour [5].
The common carp (*Cyprinus carpio*) originated in European rivers around the Black sea and the Aegean basin [6], it was introduced to Nigeria in the year 1952 by the "father" of Panyam fish farm Jos K.K Zwilling. Since the introduction of common carp to Nigeria much research work has been done both on private projects especially at the Rock water fish farm in Jos and governmental projects at the Panyam fish farm but their breeding history has gone largely unrecorded and carp breeding has not attracted much interest from individuals and research institutes in the country [7]. The culture of common carp in Nigeria is gaining popularity due to its fast growth and high market value. Little is known about the artificial breeding of this species in the country, hence the need to determine the optimal temperature for the artificial reproduction of common carp in Nigeria.

## 2. Methodology

### 2.1 Source of experimental fish and Experimental Design

Broodstock of two years old Common carp were obtained from Panyam Fish farm Jos, Plateau State, Nigeria and transported in oxygenated polythene bags to the Department of Biological Sciences, Ahmadu Bello University Zaria, Nigeria. They were acclimatized for a period of two weeks before the experiment. Eighteen (18) broodstock (9 female and 9 male) having body size ranging from 800grams to 2500grams were used for this experiment. The brooders were divided into three groups (I, II and III) of 3 females and 3 males each per group. Each of the group of brooders were induced in three different months with different water temperature regimes. Group I fishes were induced in the month of January with a water temperature of 23±1 °C, group II fishes were induced in the month of February with a water temperature of 26±1 °C and March with a water temperature of 29±1 °C for group III (Table 1).

**Table 1:** Experimental Design

| Group | Ratio of female to male brooders | Month | Temperature (°C) |
|---|---|---|---|
| I | 3:3 | January | 23±1 |
| II | 3:3 | February | 26±1 |
| III | 3:3 | March | 29±1 |

### 2.2 Inducing agent and latency determination

Ovaprim a synthetic hormone produced by Syndel Laboratories (Canada) was used for the inducement of *C. carpio* through single application. Both female and male *C. carpio* were administered single dose of the inducing hormone intramuscularly at the base of the last ray of the dorsal fin. Female brooders received a dosage of 0.5ml/Kg body weight while male brooders received 0.2ml/Kg body weight simultaneously [8, 9].

The brood fish after receiving the dosage of ovaprim were returned to a circular plastic tank containing 100 litres of water (pH 7.97-8.09, Dissolved Oxygen 4.87-6.13 ml/L, Total Dissolved Solid 285.40-311.83 ppm) under aeration. They were left undisturbed for a period of 10 hours after which they were checked periodically at thirty (30) minutes interval for ovulation indicated by the release of eggs in the spawning tanks [12]. When eggs were observed at the bottom of tanks the fish were immediately brought out and stripped. The duration of time from the inducement of the fish to the ovulation was recorded as the latency period.

### 2.3 Fecundity, fertilization and incubation of egg

To determine the fecundity of the spawners, the eggs obtained were weighed using a sensitive weighing machine (Sartorious CP8201, Capacity 0.1-8200.00g). One gram of the egg was then taken and the number of eggs contained in the 1g eggs were counted to obtain the estimate of the fecundity of the female fish.

Fertilization was accomplished using the 'dry' method; the milt was added directly on the eggs in the plastic bowl and gently stirred with chicken feather. Clean fresh water was added to activate the fertilized eggs. Stickiness of eggs was eliminated using milk and NaCl solution [10]. Unfertilized eggs have white and opaque appearance while the fertilized eggs have transparent appearance. Three sub samples of water harden eggs were taken from each set after six hours of fertilization and the number of fertilized eggs produced in each sub samples were counted. Percentage fertilization was calculated as follows;

$$\text{Fertilization rate} = \frac{\text{Total number of fertilized eggs}}{\text{Total number of eggs produced}} \times 100$$

The fertilized eggs were incubated in the McDonald incubation jars. Incubators were receiving fresh borehole water (pH 7.90-8.00, DO 5.27-6.09 ml/L, TDS 293.81-336.09 ppm) which was circulated through the water recirculatory system at a flow rate of six (6) litres per minute.

### 2.4 Hatching time and hatchability rate

The duration of time from the fertilization to the hatching of the eggs of *C. carpio* was recorded. The number of hatchlings was estimated using a volumetric method. One (1) litre of water containing the hatchlings was collected in triplicate from the aquaria tanks and the number of hatchlings in the subsamples was counted. The hatchability rate was calculated as follows;

$$\text{Hatchability rate} = \frac{\text{Number of hatched larvae}}{\text{Total number of fertilized eggs}} \times 100$$

### 2.5 Data Analysis

The statistical analysis of the results was carried out using the analysis of variance (ANOVA) to determine the significance difference ($p \leq 0.05$). Duncan's Multiple Range Test (DMRT) was used to separate means where there is significant difference. Correlation analysis (r) was carried out to determine the relationship between temperature and the various breeding parameters.

## 3. Results and Discussion

The results of breeding parameters of *C. carpio* on Table 2 showed that longest latency period of 16.55±0.13 h was observed in the fish group which were induced at the temperature of 23±1 °C, followed by the fish induced at temperature of 26±1 °C with latency of 13.00±0.13 h, while the fish which were induced at temperature of 29±1 °C had the minimal latency period of 11.32±0.07 h, the higher the temperature the lower the latency of period as indicated by the linear negative correlation coefficient (r=-0.98) as shown on Table 3.

Latency period is significantly affected by water temperature. Increase in water temperature leads to decrease in the latency of *C. carpio* these findings agrees with earlier research on *C. carpio, Labeo victorianus* [16, 12, 2]. The reason for this linear negative correlation between temperature and latency could be because in poikilothermic organisms at higher temperature metabolic activities is accelerated and their metabolism is dependent on the ambient temperature. Therefore an increase in metabolism leads to increase in the secretion of the pituitary gland which in turn release gonadotropin into the blood stream in shorter time, this release of the gonadotropin into the blood stream is what brought about the luteinisation (final maturation) and finally the release (ovulation) of the eggs by the female broodfish.

**Table 2:** Breeding indices of *Cyprinus carpio* induced with ovaprim at different temperatures

| Parameters | Temperature (°C) | | | Mean Total | P value |
|---|---|---|---|---|---|
| | 23±1 | 26±1 | 29±1 | | |
| Weight of Female Fish (g) | 1717.67±462.82 | 1639.50±199.50 | 1632.33±373.90 | 1666.13±198.95 | 0.986ns |
| Latency (Hrs.) | 16.55±0.13[a] | 13.00±0.13[b] | 11.32±0.07[c] | 13.70±0.87 | 0.000** |
| Weight of Eggs (g) | 76.67±23.15 | 85.70±7.10 | 82.87±14.47 | 81.25±9.15 | 0.942ns |
| Fecundity | 53666.67±16207.85 | 59990.00±4970.00 | 58006.67±10126.67 | 56875.00±6401.72 | 0.942ns |
| Number of Viable Eggs | 52356.50±15744.86 | 58281.00±4471.00 | 55742.87±9806.31 | 55107.51±6193.93 | 0.950ns |
| Percentage (%) Fertilization | 72.67±1.76[ab] | 89.00±3.00[a] | 52.30±10.49[b] | 69.11±6.51 | 0.047* |
| Hatching Duration (Hrs.) | 41.96±0:42[a] | 37.18±0:04[b] | 28.98±0.96[c] | 35.87±2.15 | 0.000** |
| Percentage (%) Hatchability | 46.83±0.84[b] | 67.50±2.50[a] | 28.58±10.08[c] | 45.16±6.62 | 0.033* |

Means along the same row with different superscript alphabet(s) were significantly different (p≤0.05)

**Table 3:** Relationship between temperature and various breeding indices of *Cyprinus carpio*

| | Temperature | Wt. of female fish | Latency | Wt. of egg | Fecundity | No. of viable eggs | % fertilization | % hatchability |
|---|---|---|---|---|---|---|---|---|
| Temperature | 1.00 | | | | | | | |
| Wt. of female fish | -0.07 | 1.00 | | | | | | |
| Latency | -0.98* | 0.06 | 1.00 | | | | | |
| Wt. of egg | 0.11 | 0.97* | -0.14 | 1.00 | | | | |
| Fecundity | 0.11 | 0.97* | -0.14 | 1.00 | 1.00 | | | |
| No. of viable eggs | 0.09 | 0.97* | -0.12 | 1.00 | 1.00 | 1.00 | | |
| % fertilization | -0.51* | 0.23 | 0.37 | 0.18 | 0.18 | 0.20 | 1.00 | |
| % hatchability | -0.45* | 0.06 | 0.30 | 0.08 | 0.08 | 0.09 | 0.94* | 1.00 |
| hatching time | -0.98* | -0.02 | 0.94* | -0.18 | -0.18 | -0.15 | 0.62* | 0.59* |

Correlation (r) with * indicate a strong relationship between the two parameters which intercepted

The results on weight of eggs produced, fecundity and number of viable eggs shows that temperature has no significant effect on them. Weight of female brooders was positively correlated (r = 0.97) with the weight of eggs produced, fecundity and number of viable eggs. Similar results were found by other researchers [12, 15, 18].

Fertilization of *C. carpio* was highest (89.00±3.00%) in the fish induced at temperature of 26±1 °C followed by 72.67±1.76% at 23±1 °C and lowest fertilization rate of 53.30±10.08% was found in the fish induced at temperature of 29±1 °C (Table 2). A similar result was found when *Labeo victorianus* was induced with ovaprim (0.5mg $kg^{-1}$) at different temperatures [18].

The significant decrease in fertilization rate at higher temperature of 29±1 °C could be that this temperature is closer to the thermal tolerance limit of *C. carpio* eggs. Temperature affects the quality and size of eggs produced [19, 20]. Moreover, temperature is responsible for the period of final gamete maturation (FGM) in fish and can even inhibit the reproduction process or reduce the larvae survival rate to 0% [21, 22]. Fertilization involves the action of the gamete (egg) from the female fish as well as the gamete (Milt) from the male fish and it is a known fact that sperm motility is a key prerequisite for determining the quality and fertilizing ability of semen. It has been confirmed that spermatozoa are motile for longer at 20 °C than at 26 or 30 °C in common carp or 30 °C in grass carp [24, 23].

The results of hatching time of *C. carpio* eggs in table 2 showed that, at temperature of 23±1, 26±1 and 29±1 °C hatching time was found to be 41.96±0.42, 37.18±0.04 and 28.98±0.96 hrs respectively, the hatching time in the present research tend to be lesser when compared with findings of other researchers on the hatching time of *C. carpio* [8, 11, 25, 26]. The reduced hatching time in the current study could be due to some unknown factors (environmental, water quality, genetic variation, management of the broodstocks etc) which may favour the hatching process of *C. carpio.* The result of relationship between temperature and hatching time in Table 3 showed that temperature is negatively correlated (r = -0.98) with hatching time. Increase in temperature results in a significant decrease in the hatching time of *C. carpio.*

The results of the effect of temperature on the percentage hatchability of *C. carpio* eggs in the present study was found to be 46.83±0.84, 67.50±2.5 and 28.98±10.08% for the temperature group of I, II and III respectively (Table 2). The group II fishes with temperature of 26±1 °C had the highest percentage hatchability followed by the group II fishes while the group III fishes with incubation temperature of 29±1 °C had the least hatchability. Higher hatchability was found by other researcher [5, 18], the findings in the current study agrees with other findings [26]. A finding on *Clarias gariepinus* showed that temperature had no effect on the hatchability of the fish [27]. The reason for the reduced hatchability rate at elevated temperature of 29±1 °C could be due to the lethal effect of higher temperature on the developing embryos; since the developing embryos are fragile and their resistance to environmental stress is minimal.

## 4. Conclusion

The monthly variation in water temperature has a significant effect on the artificial breeding of common carp. Latency period, hatching time, fertilization and hatching rate decrease with increase in water temperature. The fish artificially bred in the month of February with water temperature of 26±1 °C performed best in terms of fertilization (89.0±3.0%) and hatchability rate (67.5±2.5%).

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