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Research Article
Survival Rate and Reproductive Traits of *Clarias jaensis* Broodstock Reared at Graded Levels of Water Temperature in West Region of Cameroon

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Abstract

Background and Objective: In areas such as the Western Region of Cameroon with an equatorial climate, breeders of fish broodstock still face many production problems such as a water temperature level responsible for optimal fish reproduction performance. The objective was to evaluate the effects of graded levels of temperature on survival rate and reproductive traits of *Clarias jaensis* in areas with equatorial climates. **Materials and Methods:** A total of 32 broodstock of *Clarias jaensis* (16 females and 16 males). The females were randomly divided into four batches at comparable temperature, namely batches 1, 2, 3 and 4, respectively for temperatures between 22-23, 25-26, 27-28 and 30-31°C. During the experimentation, data were collected on survival rate, condition factor, fertility and hatching indices. A descriptive statistics and one-way ANOVA were used to test the reproduction characteristics in different temperature levels. **Results:** The survival rate of female *Clarias jaensis* was significantly ($p<0.05$) higher in batches T0 (100%) and T1 (100%) compared to that of batch T2 (80%). However, no females survived in the T3 treatment. Fish subjected to 22-23°C (T0) and 25-26°C (T1) recorded the same 56% higher spawning rate than those subjected to 27-28°C (46%). The weight and the diameter of the oocytes before induction and after stripping was not affected by temperature. However, the higher latency time was in the females with the T0 treatment and T1 treatment has lowest rate. Absolute and relative fecundity, fertilization rate and hatchability were significantly ($p<0.05$) affected by increasing temperature levels. **Conclusion:** Based on the results of the present study, it can be recommended to rare the broodfish of *Clarias jaensis* at a temperature between 25 and 28°C in the tropics for better reproductive traits.

Key words: *Clarias jaensis*, fish broodstock, survival rate, fish fertility rate, egg hatching rate, water temperature

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

In Cameroon, the level of animal protein consumption in terms of meat is 13.07 kg per capita per year. This is below the standard of 42 kg per capita per year recommended by the Food and Agricultural Organization (FAO) for a proper diet[1]. Fish is one of the main sources of animal protein in Cameroon, as in many developing countries covering nearly 50% of needs and it can be used as a model to fill this meat deficit[1]. Fish is a real local resource than meat because its high price cannot be replaced. It is an essential source of protein and trace elements, very valuable for nutritional balance and health (rich in long-chain omega 3 and low in cholesterol), which represents about 40% of the protein intake of animal origin and 9.5% of the total needs of the population[2]. Currently, the consumption of fishery products (such as shrimps, prawns, crabs, sardinella, cod fish, sole, mackerel, bars and tuna) is around 16.9 kg/inhabitant. However, increasing population pressure not well matched to fish has caused pressure on the demand for fishery products. Hence, the need for aquaculture to alleviate these problems of market demands for fish and fishery products[3]. In Cameroon, national fish production is only 180,000 ton with less than 15,000 ton/year coming from aquaculture. This remains low for an annual demand estimated at 400,000 ton[4]. To fill this gap, (181,678 ton of fish) products were imported in 2017[4]. Moreover, the very modest annual aquaculture production of 330 ton contributes less than 1% to the Gross Domestic Product (GDP). The sector provides about 15 to 20,000 direct jobs and is a source of additional income for many rural families[5]. Meanwhile the country has a dense hydrographic network, comprising several rivers (3% of the surface area of Island water), natural lakes (4%), reservoir dams (7%), flood plains and marshes (86%), as well as many sites available for aquaculture. This hydrographic network offers the potential for a very diverse fish species, with 542 species of fish over more than 400.000 km^2 surfaces in fresh water[6]. *Clarias jaensis* is an indigenous species in Cameroon that is still being domesticated, it is found in the Mbô floodplains, Sanaga, Nyong, Lobe, Kribi[7]. It is one of the fish species being appreciated by consumers for the quality of its fleshy and palatable white meat, carcass yield with high economic and nutritive value which are higher than those of fish species currently grown in Cameroon (*Cyprinus carpio*, *Oreochromis niloticus*, *Heterotis niloticus*, *Parachanna obscura*). It is an ideal candidate to resolve the high price of meat most especially white flesh in underdeveloped and developing countries[8]. The breeding of Clariidae in particular *Clarias jaensis* is still confronted with numerous technical problems in particular that of temperature which is difficult to control by breeders. Thus, temperature has an impact on the survival and reproductive performance of fish. Several researches have been carried out on the domestication of *Clarias jaensis* particularly on the feeding regime to evaluate the growth performance[9]. Other research on the domestication of *Clarias jaensis* to evaluate the energy requirement for growth and reproduction[10] and on the protein requirement for growth and reproduction[11]. Other domestication work was carried out on *Clarias jaensis* by Zango *et al.*[12] and Tiogué *et al.*[13] on the characteristics of reproduction in the natural and controlled environment. Research by many authors[14-16] in view of the effect of temperature on the survival rate and reproductive performance of several species of fish such as *Oreochromis niloticus*, *Clarias gariepinus*, *Cyprinus carpio*, these recent years. These studies have been done on different species and in different climatic zones. Also, the number does not seem important in equatorial climates such as ours; to the best of our knowledge no information is currently available on the study of temperature on *Clarias jaensis*, so breeders of our locality are still confronted with this problem of temperature. It is important to know the role of the graded level of water temperature on the survival rate and reproductive traits of *Clarias jaensis* for successful operations in the hatchery. The present study aims to improve the reproductive traits of fish in captivity.

MATERIALS AND METHODS

Period and study area: This study started from February to May, 2023 and was conducted at one of the Cameroonian Cooperative for Fisheries Development Unit in Bafoussam located in the Western Region of Cameroon, in the Mifi Division and District of Bafoussam 1st. The district commune of Bafoussam 1st is located between 5°25 of North Latitude and 5°30 of East Longitude. It has a highland Cameroonian climate with two seasons: A dry season from mid-November to mid-March and a rainy season from mid-March to mid-November. Average annual rainfall varies between 1600 to 2000 mm, with August being the wettest month. The climate is favorable for agro-sylvo-pastoral activities.

Animal material: Sixteen females *Clarias jaensis* broodstock (Fig. 1) with an average weight of 333.27±143 g and sixteen males of *Clarias jaensis* with an average weight of 426.46±154.2 g were used. They were captured by a fisherman in a natural river in Bafoussam 3rd. The broodstock was kept in separate polythene buckets (160 L) with perforated lids and transported in a taxi through the experimental area.

Fig. 1: Brood stock of *Clarias jaensis*

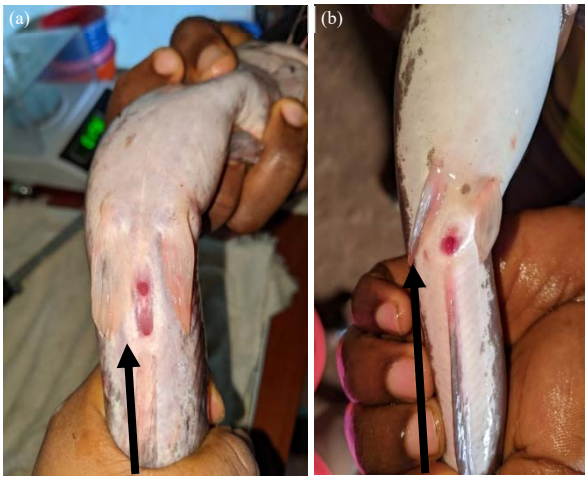

Fig. 2(a-b): Ventral view of both gravid male and female genital papilla, (a) Ventral view of *C. jaensis* gravid male showing male genital papilla and (b) Ventral view of *C. jaensis* gravid female showing female genital papilla

Experimental set-up: A total of 16 rectangular polyethylene basins with a useful volume of 35 L were used for the stabilization of 16 females after hormonal induction. These basins were placed on wooden supports fed by gravity in an open circuit using a junction. The water source was from the tap located near the hatchery. Sixteen females with 333. As 27±143 g were divided randomly into four comparable temperature treatments with T0 (22-23°C) which served as the control batch; T1 (25-26°C), T2 (27-28°C) and T3 (30-31°C), respectively which were the test batch. Therefore, the randomized experimental plan was 04 treatments and 04 replicates per treatment for the female brood stock. The incubation of eggs up to hatching had a total of 16 rectangular polyethylene basins with useful volumes of 35 L. These temperatures were stabilized with the aid of heaters connected to different adjustable program timers for 1 hr and 30 min each.

Conduct of experiment:

- **Collection, storage and management of brood stock:** The brood stock (male and female) was captured by a fisherman in Bafoussam. Thereafter separate-sex brood stocks were kept in 160 L buckets each for two days without feed
- **Broodstock selection:** The selection of gravid brood stock was based on the following criteria:
  - **Choice of male:** Fully gravid males with an average weight of 426.46±154.2 g were identified by their slender and streamlined bodies with conical and elongated genital papilla having pointed reddish tips. The aspect of aggressiveness was also observed
  - **Choice of female:** Gravid female fish with an average weight of 333.27±143 g were identified by the presence of soft swollen bellies with short, round, button-shaped and slit-like genital papilla along with a reddish vent. Prime maturity of the female was determined by examining the size uniformity of the eggs released by the gentle pressure on the swollen abdomen. Thereafter, in the hatchery, the oocytes were taken from each female using a spatula and their oocyte weight and diameters were measured using a sensitive scale balance and millimetric paper, respectively. Sixteen females with an oocyte weight of 4.59±1.10 mg and diameter of 1.90±0.22 mm were selected and kept for 48 hrs in a holding basin. Some external characteristics of brood stock were presented in the Fig. 2a for male and Fig. 2b for female
- **Hormonal induction:** To induce oocyte maturation, the synthetic hormone "ovaprim" which contains as an active ingredient Gonadotropin Releasing Hormone analogue (sGnRH) and domperidone (DOM) was used with a dose of 0.5 mg kg^{-1} of stock solution was induced per kg of body weight. Each female received one injection whereby the administered dose was proportional to the weight of the fish. Males were not injected. The induction time was recorded with the aid of a stopwatch. Thereafter, the females were placed in different temperature treatments (22-23, 25-26, 27-28 and 30-31°C) in 16 different basins with water-renewable systems and the different temperatures were regulated using two different thermostat heater (GB01.3064)

Harvesting of gametes: For each female, oocyte maturation and ovulation were obtained after a mean latency period of 32 hrs according to different values of temperature. The milt was collected using a technique of partial gonadectomy as described by Tiogué *et al.*[17] and then diluted with a physiological solution (0.9% NaCl) to activate fertilization. Females were weighed before the eggs were obtained by slight manual abdominal pressure and collected in well-dried tagged plastic bowls and weighed on a sensitive balance of precision 0.1 g.

Fertilization and incubation: The collected gonads were weighed and dissociated with sterile dissecting blades to obtain the milt. The milt was thereafter mixed with the oocytes in bowls for fertilization between female *Clarias jaensis* and male *Clarias jaensis*. A small amount of physiological solution (10 mL of 0.9% NaCl) was used to rinse the mixture for 1 min and thereafter spread on incubation trays (1 mm mesh) in each basin raised at different water temperatures (intervals between 22-23, 25-26, 27-28 and 30-31°C) connected in a closed circuit system powered with submersible pumps of capacity 43W regulated with a programmer timer at 1 hr, 1 hr 15 min and 1 hr 30 min for the test batch (25-26, 27-28 and 30-31°C), respectively. One bowl containing unfertilized oocytes of each cross was used to as a control to evaluate the fertilization rate. Thermostats of capacity each 500 and 1500 W and the time of incubation recorded for each. The time taken by the eggs to become white was recorded and all other eggs were considered to be fertilized and counted to assess the fertilization rate.

Water parameter analysis: Before the beginning of trial, the pH, salinity, conductivity and dissolved oxygen of water used defined. Table 1 shows the physicochemical parameters of the water before the beginning of the trial.

Study parameters and data collected

Survival rate of female *C. jaensis*: The survival rate was obtained by using the formula developed by Tiogué *et al.*[17]:

$$\text{Survival rate (\%)} = \left(\frac{Nf}{Ni}\right)\times 100$$

So:

$$Nf = Ni - Ndeath$$

Where:

Nf = Final number of female
Ni = Initial number of females

Reproductive parameters:

- **Condition factor (k):** The standard lengths of females selected for hormonal induction of *Clarias jaensis* were measured using an itchyometer (Wildco® Fish Measuring Board 30 in, United States). Then weighed individually before stripping using a digital scale balance (SF-400, China) with a precision of 1 g. A second weighing was carried out just after stripping. These were used to determine the k-factor:

$$K^2 = \frac{TW\text{-}WG}{SL^3}$$

Where:

K = Condition factor
TW = Total weight of fish (g)
WG = Weight of gonads
SL = Standard length of fish (cm)

- **Oocyte diameter:** Oocyte diameter was obtained by averaging the distance over 10-15 oocytes measured on a millimeter graph paper as described by Zango *et al.*[12]
- **Fecundity:** Both absolute and relative fecundity was determined as follows:
  - **Absolute fecundity (aF):** Total number of ripe oocytes present in the ovaries of each female immediately before spawning was counted according to Dadebo *et al.*[18]
  - **Relative fecundity (rF):** It was assessed according to the formula developed by Tiogué *et al.*[17]:

$$\text{Relative fecundity (rF)} = \frac{Pe \times aF}{Pa}$$

Where:

Pe = Weight of oocytes laid in g = Pa-Pf with
Pa (g) = Weight of the female before spawning
Pf (g) = Weight of the female after spawning

Table 1: Physicochemical parameters of the water

Parameters	Values
pH	6.56±0.17
Conductivity (mS cm^{-1})	68.4±5.89
Salinity (ppt)	33.7±4.37
Dissolved oxygen (mg L^{-1})	0.13±0.07

pH: Potential of hydrogen and ±: Mean±SD

Latency time: The injection of hormone solution was simultaneously in different batches of females for each treatment. Then after each injection, the time and date were recorded and placed in an open circuit medium, 12 hrs after injection, the females were checked every 3 hrs and after 24-48 hrs they were observed every 30 min in order to observe natural expulsion of oocytes. The oocyte time expulsion is confirmed when the females turn their backs and let the oocytes flow out naturally with a central micropile.

The latency time was calculated by the difference between the hour of hormonal injection and that of the oocyte collection (stripping) according to the method described by Chen *et al.*[16].

- **Spawning rate:** Spawning rate was assessed when oocyte maturation was observed, whereby each female was removed from her holding tank while releasing eggs naturally by herself. Each female was weighed before stripping and thereafter a second weighing after stripping with the aid of a digital scale balance with a precision of 1 g (SF-400, China). Then the weight of oocytes collected per female was weighed using a sensitive scale balance with a precision of 0.1 g. All these data made it possible to determine the spawning rate as follows:

$$\text{Spawning rate (\%)} = \left(\frac{\text{Woi}}{\text{Wof}}\right)\times 100$$

Where:
Woi = Total weight of oocytes collected
Wof = Weight of females

- **Fertilization rate:** It was determined using the formula given by Tiogué *et al.*[17]:

$$\text{Fertilization rate (\%)} = \left(\frac{\text{Nof}}{\text{Noi}}\right)\times 100$$

Where:
Nof = Total number of fertilized eggs
Noi = Total number of eggs incubated

- **Embryo rate:** It was determined by counting the number of white eggs against the normal eggs:

$$\text{Embryo rate} = \frac{\text{Number of white eggs}}{\text{Total number of eggs}}\times 100$$

Hatching rate: The incubation trays were turned upside down before being removed from the basins. This action allows the hatched larvae to fall directly to the bottom of the basin, limiting the risk of massive fungal growth caused by unhatched eggs. The enumeration of larvae was made by direct observation with the naked eyes in the presence of light. The hatching rate was determined using the formula developed by Chen *et al.*[16]:

$$\text{Hatching rate (\%)} = \left(\frac{\text{NL}}{\text{Nof}}\right)\times 100$$

Where:
NL = Total number of larvae obtained at hatching (normal, deformed and dead)
Nof = Total number of fertilized eggs

Statistical analysis: The data collected was recorded in Microsoft Excel. A series of descriptive statistics was used to determine the mean, standard deviation and percentage of the various characteristics. The one-way ANOVA was used to compare the mean values for the reproduction characteristics in different temperature levels. When the differences were significant, they were separated by Duncan's Multiple Tests at the 5% significance ($p<0.05$). All analyses were done using SPPS (Statistical Package of Social Sciences) version 20.0. All histograms were plotted using Excel 2010 software.

RESULTS

Variation in the survival rate of female *Clarias jaensis* reared in graded levels of water temperature: The survival rate of female *Clarias jaensis* reared in graded water temperature levels. It appeared that the female survival rate was 100% in both the T0 and T1 treatments and 80% in T2 treatment. Nevertheless, no female survived in the T3 treatment as shown in Fig. 3.

Effect of temperature on reproductive traits in *Clarias jaensis*

Effect of temperature on female condition factor k in *Clarias jaensis*: The effect of temperature on female condition factor k was presented in Fig. 4. It shows that the temperature level considered did not significantly ($p>0.05$) affect the female *Clarias jaensis* condition factor. However, the females subjected to temperatures of 27-28°C (T2) treatment recorded a higher condition factor k (0.89) compared with those subjected to T0 treatment (0.79) and T1 treatment (0.78). None of the females exposed to T3 resisted.

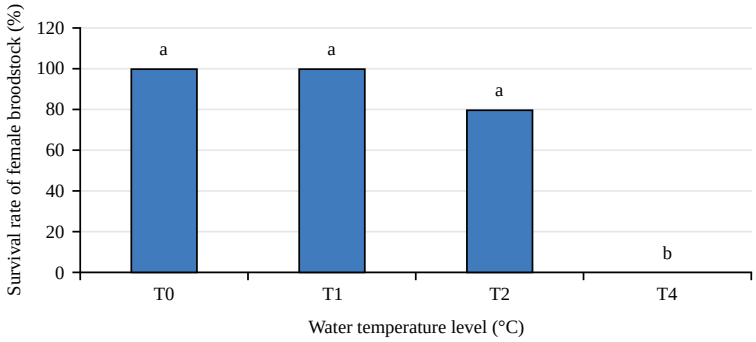

Fig. 3: Variation in the survival rate of female *Clarias jaensis* in terms of temperature (°C)

[ab]Histograms having the same letter do not differ significantly (p>0.05), T0: Treatment subjected to 22-23°C, T1: Treatment subjected to 25-26°C, T2: Treatment subjected to 27-28°C and T4: Treatment subjected to 30-31°C

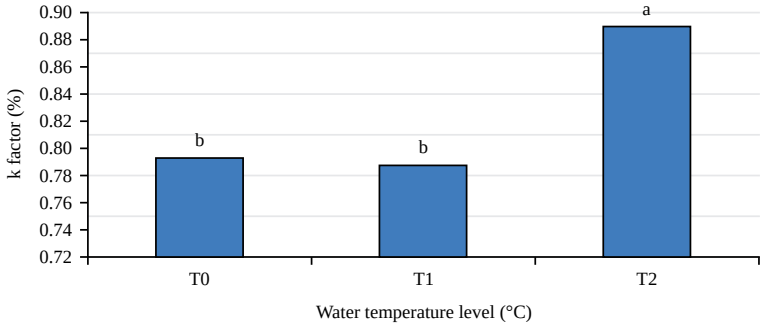

Fig. 4: Effect of temperature on female condition factor k before and after stripping in *Clarias jaensis*

[ab]Histogram having the same letter do not differ significantly (p>0.05) T0: Treatment subjected to 22-23°C, T1: Treatment subjected to 25-26°C and T2: Treatment subjected to 27-28°C

Variation of latency time in female *Clarias jaensis* in terms of temperature: Table 2 summaries the variation of latency time in female *Clarias jaensis* according to graded levels of water temperature. It shows that, whatever the temperature range considered, the latency time significantly ($p<0.05$) varied during the study. However, a higher latency time 44:43:30 was recorded in females subjected to T0 treatment as compared to that of T2 treatment 28:58:00. The T1 treatment had the lowest latency time 23:47:29.

Variation of oocyte weight and diameter in terms of temperature before induction and after stripping in *Clarias jaensis*: The variation of oocyte weight (mg) and diameter (mm) according to graded levels of water temperature in *Clarias jaensis* was presented in Table 3. It shows that, the temperature whatever the level did not significantly affect the oocyte weight and diameter before induction and after stripping. When considering only the oocyte weight, the value recorded in the T1 treatment after stripping was significantly increase in reference to that noted before induction. In the rest of the treatments the oocyte weight before induction and after stripping were comparable ($p>0.05$). As for the oocyte diameter the values recorded before induction were compared to those after stripping.

Variation of absolute fecundity and relative fecundity in terms of temperature in *Clarias jaensis*: Table 4 summaries the variation of absolute and relative fecundity in terms of temperature in *Clarias jaensis*. As a result, the absolute and relative fecundity was significantly ($p<0.05$) affected by the graded levels of temperature. However, the absolute fecundity recorded in T1 and T2 treatments were comparable but significantly lower than that in the T0 treatment. For the relative fecundity, a significantly higher value was recorded in the T2 treatment while the lower was in the T1 treatment.

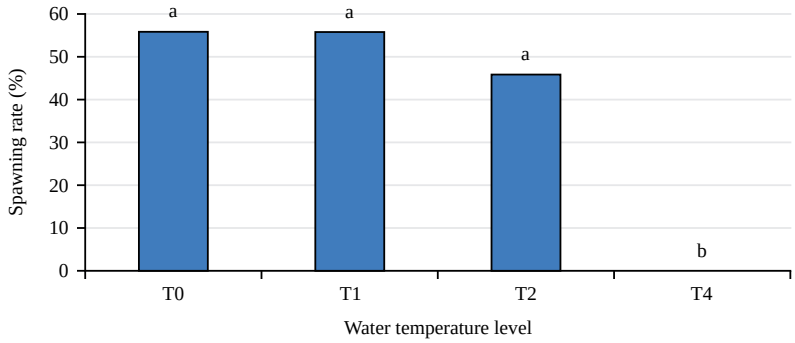

Fig. 5: Variation of spawning rate in terms of temperature in *Clarias jaensis*

[ab]Histograms having the same letter do not differ significantly (p>0.05), T0: Treatment subjected to 22-23°C, T1: Treatment subjected to 25-26°C, T2: Treatment subjected to 27-28°C and T4: Treatment subjected to 30-31°C

Table 2: Variation of latency time in female *Clarias jaensis* in terms of temperature

	Water temperature level				
Latency time (hrs)	T0	T1	T2	T4	p-value
Mean	44:43:30±6:59:45[a]	23:47:29±0:05:26[b]	28:58:00±1:15:23[b]	/	0.00
Maximum	49:00:00	23:51:59	30:24:59	/	
Minimum	34:16:00	23:51:59	28:12:00	/	

[ab]Values affected with the same letter in the same line are not significantly different (p>0.05). T0: Treatment subjected to 22-23°C, T1: Treatment subjected to 25-26°C, T2: Treatment subjected to 27-28°C and T4: Treatment subjected to 30-31°C

Table 3: Variation of oocyte weight (mg) and diameter (mm) in terms of temperature before and after stripping in *Clarias jaensis*

	Water temperature level				
Reproductive parameters	T0	T1	T2	T4	p-value
Oocyte weight (mg)					
Before induction	5.30±1.27	4.49±1.06	4.72±1.54	4.61±0.52	0.57
After stripping	5.38±1.86	5.85±0.73	4.87±0.90	/	0.44
Oocyte diameter (mm)					
Before induction	1.90±0.12	1.90±0.12	1.97±0.28	1.81±0.19	0.19
After stripping	1.95±0.15	2.00±0.16	2.01±0.15	/	0.14

T0: Treatment submitted to 22-23°C, T1: Treatment submitted to 25-26°C, T2: Treatment submitted to 27-28°C and T4: Treatment submitted to 30-31°C

Table 4: Variation of absolute and relative fecundity in terms of temperature in *Clarias jaensis*

	Water temperature level				
Reproductive parameters	T0	T1	T2	T4	p-value
Absolute fecundity (aF)					
Mean	10329.42±1295.30[a]	6472.01±835.05[b]	7194.73±525.46[b]	/	0.00
Maximum	11662.76	7348	7720.20	/	
Minimum	9075.84	5340.01	6669.27	/	
Relative fecundity (rF)					
Mean	22.44±0.24[b]	17.17±2.37[c]	27.29±1.34[a]	/	0,00
Maximum	22.68	19.65	28.64	/	
Minimum	22.21	14.01	25.95	/	

[abc]Values affected with the same letter in the same line are not significantly different (p>0.05), T0: Treatment submitted to 22-23°C, T1: Treatment submitted to 25-26°C, T2: Treatment submitted to 27-28°C and T4: Treatment submitted to 30-31°C

Variation of spawning rate in terms of temperature in *Clarias jaensis*: The variation of spawning rate in *Clarias jaensis* according to graded levels of water temperature was illustrated in Fig. 5. It appears that the spawning rate decreased with an increase in temperature level. The fish subjected to 22-23°C (T0) and 25-26°C (T1) recorded the same higher spawning rate of 56% as compared to those subjected to 27-28°C (46%). None of the females subjected to T3 treatment resisted during the trial.

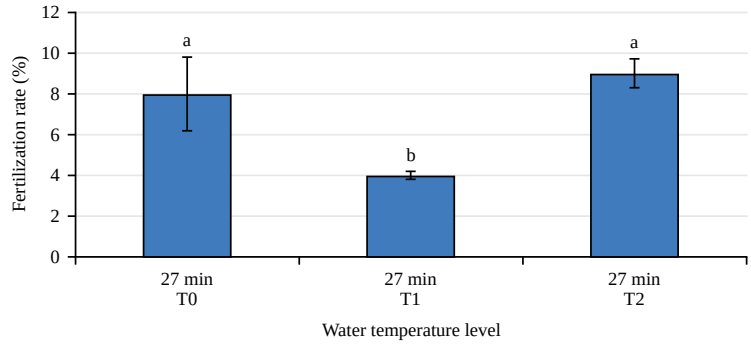

Fig. 6: Fertilization rate of eggs according to graded levels of water temperature in *Clarias jaensis*

[ab]Histograms having the same letter do not differ significantly (p>0.05), T0: Treatment subjected to 22-23°C, T1: Treatment subjected to 25-26°C and T2: Treatment subjected to 27-28°C

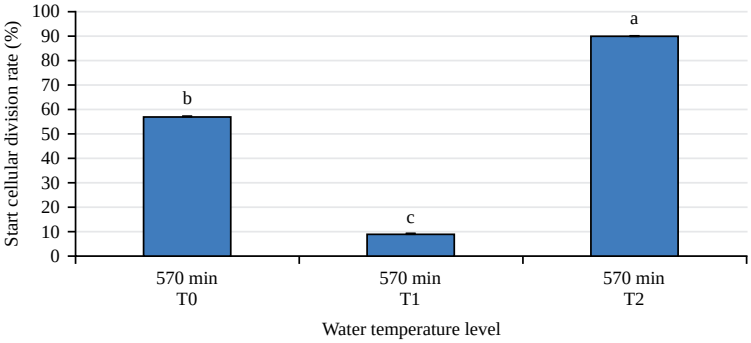

Fig. 7: Start of cellular division eggs according to graded levels of water temperature in *Clarias jaensis*

[ab]Histograms having the same letter do not differ significantly (p>0.05), T0: Treatment subjected to 22-23°C, T1: Treatment subjected to 25-26°C and T2: Treatment subjected to 27-28°C

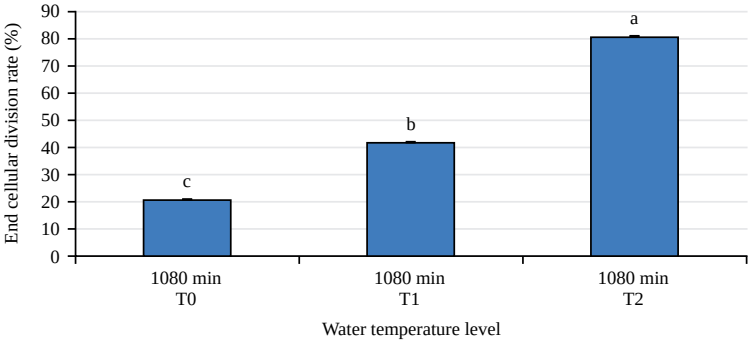

Fig. 8: End of cellular division eggs according to graded levels of water temperature in *Clarias jaensis*

[ab]Histograms having the same letter do not differ significantly (p>0.05), T0: Treatment subjected to 22-23°C, T1: Treatment subjected to 25-26°C and T2: treatment subjected to 27-28°C

Variation of eggs according to different graded levels of water temperature in *Clarias jaensis*: The e fertilization rate, start of cellular division, end of cellular division, embryo rate and hatching rate were shown in Fig. 6-10. The fertilization rate (9%) and start of cellular division (90%) were significantly higher in the T2 treatment than in T1 (4 and 10%, respectively for fertilization rate and start of cellular division). As what concerns the end of cellular division, embryo rate and hatching rate, the higher values (81, 42 and 87%, respectively) were observed in T2 treatment and the lowest values (21, 1 and 0%, respectively) in the T0 treatment.

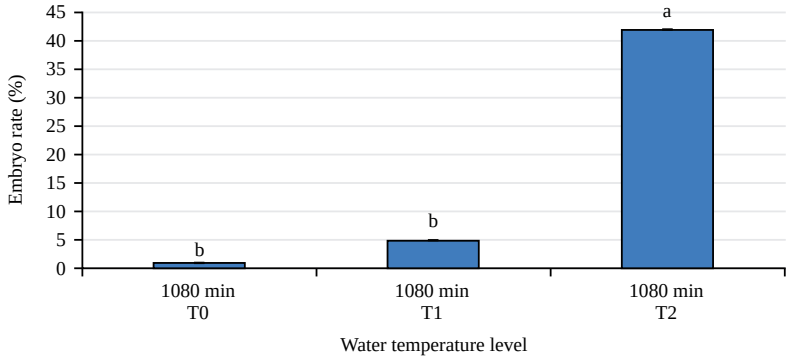

Fig. 9: Embryo rate of eggs according to graded levels of water temperature in *Clarias jaensis*

[ab]Histograms having the same letter do not differ significantly (p>0.05), T0: Treatment subjected to 22-23°C, T1: Treatment subjected to 25-26°C and T2: Treatment subjected to 27-28°C

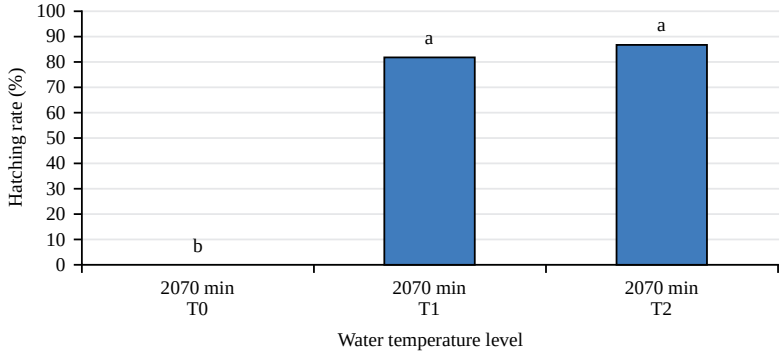

Fig. 10: Hatching rate of eggs according to graded levels of water temperature in *Clarias jaensis*

[ab]Histograms having the same letter do not differ significantly (p>0.05), T0: Treatment subjected to 22-23°C, T1: Treatment subjected to 25-26°C and T2: Treatment subjected to 27-28°C

DISCUSSION

In the present study, survival rates of *Clarias jaensis* broodstock varied between 100% (temperature level of 22-23 and 25-26°C) and 80% (27-28°C). They survival rate recorded at 25-26°C in this investigation was higher than 40% reported by Okunsebor *et al.*[19] in *Heterobranchus bidorsalis* reared at 26°C. Contrary, the survival rate of 80% noted at 27-28°C was lower relative to 100% at 28°C reported by Kasihmuddin *et al.*[15]. The mortalities in elevated temperature in this study could be explained by the effects of thermic stress on fish during the trial. This effect was more justified with 30-31°C in which no female survived.

The condition factor k values obtained in this study were below 1 whatever the levels of temperature considered. They were in line with the results of Okunsebor *et al.*[19] and Robinson *et al.*[20], who obtained 0.53 and 0.41 on *Oncorhynchus clarkii henshawi* at 24 to 26°C, respectively. The values obtained in the present study were contrary to those reported by Mazumder *et al.*[21] revealing that condition factors in the initial and final measurements of *Lutjanus malabaricus* varied from 1.73 to 1.90 and 1.73 to 2.10, respectively with increasing temperature from 22 to 30°C, indicating the well-being of the fish and slowed down gradually for those fed on pellet diet at 34°C. This difference can be explained by species, age, breeding conditions, duration of breeding of fish, the breeding environment, the degree of food source availability, the stage of sexual maturity, the relationship used to determine the K factor (Pt/Lt^3 vs Pt/Lt^b) and the length of rearing and seasonal variations. The K<1 means that the fish are doing very badly and K>1 means that they are healthy and that K varies according to sex, season, stage of maturation, degree of development muscle and lipid reserve[22].

The mean values of latency time obtained in this study were irregular in the study according to different treatments: 44 hrs for females subjected to 22-23°C, 23 hrs for females exposed to 25-26°C and 28 hrs for 27-28°C. The mean values obtained in this present study are contrary to those reported by Zango *et al.*[12], who reported 31 hrs for temperature of 20.5°C with human chorionic gonadotropin at a dose of 3500 to 4500 UI kg^{-1}. According to Zango *et al.*[12], the latency time decreases with increasing temperatures. These irregular results obtained in the present trial might be due to the manipulations during the hormonal injection dose used which will obviously have an impact on the time of the natural release of eggs. However, the latency period is an important event in the artificial breeding of fish so as not to lose quality eggs and also not to have eggs that are not ready for fecundity.

The results obtained for oocyte weight in the T1 treatment (5.85±0.73) increased in this study shows that it is independent of temperature but instead due to the water flow rate as reported by Chen *et al.*[16], who obtained mean oocyte weight of 0.24±0.01 in *Oreochromis niloticus* at high water flow rate of 0.35 Ls^{-1}. Nevertheless, there is no closeness between the values due to the difference in species and age of females used. On the other hand, the oocyte diameter values obtained were closer to the one obtained by Zango *et al.*[12] in *Clarias jaensis* (2.10±0.35). It therefore, shows that temperature has no impact on the oocyte diameter.

The results of absolute fecundity obtained in graded level of temperature between 25-26°C (6472.01±835.05) were closer to that obtained by Zango *et al.*[12] in *Clarias jaensis* (6383±5065) ova in captivity. The relative fecundity obtained in this study (22.44±0.24) in the T0 treatment was closer to that obtained by Zango *et al.*[12], who obtained 22.11 – 88.93 ova in the natural environment. These differences in values of absolute and relative fecundity obtained in this study might be due to the different ages, stages of sexual maturity and the dose of hormone used. Stress factors such as handling and confinement can block different phases of gametogenesis or affect the fecundity or quality of gametes.

The result spawning rate obtained in this study (56%) in both the T0 and T1 treatments; 46% in the T2 treatment was different from that obtained by Phelps *et al.*[23], who reported that the spawning rate in channel catfish was 52.9±51.4, 82.4±39.3 and 95 held at 24, 26 and 28°C. These low results could be attributed to the species since in general *Clarias jaensis* does not often produce a large quantity of eggs. Another reason could be due to the fact that the fish used were not at the same stage of sexual maturity.

The highest value of fertilization rate in this trial was 9% in the T2 treatment (27-28°C) which was contrary to those obtained by Okunsebor *et al.*[19]. The authors obtained a fertilization rate of 85% at 28°C in *H. bidorsalis*. This difference can be explained by the fact that the males used for T2 treatment did not have enough spermatozoa present in their milt. The highest embryo rate observed in this experiment was 42% in the T2 (27-28°C). This result was different from those obtained by Phelps *et al.*[23], who had the best temperature range for embryonic development at 26°C in channel catfish (*Ictalurus punctatus*). This difference can be explained by the fact that temperature affects the increasing metabolic rate of fish embryo, hence fish embryo are born prematurely which affect their viability[24]. Concerning the hatching rate, the highest value was 87% in the T2 treatment (27-28°C) followed by the T1 treatment (82%). These results were closer to those obtained by Waspodo[24], who revealed values of 84.33% in catfish (*Pangasius* sp.) at 29°C. Nonetheless, hatching did not take place in the T0 treatment. This can be explained by the fact that the milt did not have quality spermatozoa to obtain quality embryos. Another reason attributed is due to the no oxygen level in the T0 treatment. On the other hand, cold water delays both morphogenesis and enzyme secretion. In water that is too cold, the embryo will not hatch because enzyme production will have been delayed. However, the larva continues to develop inside the eggshell and it is only when temperatures return to suitable conditions that it will be released as a larva that is more developed than normal.

CONCLUSION

At the end of this study on the effect of graded levels of water temperature on the survival rate and reproductive traits of *Clarias jaensis* broodstock the survival rate was the highest in the temperature level ranged from 25-28°C. Also, the best reproductive traits such as spawning rate, fertilization rate, embryo and hatching rate were recorded with the same temperature interval.

SIGNIFICANCE STATEMENT

This study discovered that in the western region of Cameroon with equatorial climate, the water temperature from 25-28°C is suitable for *Clarias jaensis* broodstock breeding. At 25-28°C temperature, the highest values of survival rate and reproductive characteristics such as spawning rate, fertilization rate, embryo and hatching rate were recorded. Above 28°C, no female survived in this study. In the other hand, the fish submitted to the temperature below 25°C have shown a poor reproductive performance. In future, it would be advisable to do the same work on ontogenesis of fish embryo.

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