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Effects of photoperiod on male African giant rat (Cricetomysgambianus) reproductive parameters in captivity

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Abstract:
Background*: In captivity, African giant rat (AGR) is usually reared under a different photoperiod than in its natural habitat. Therefore, the aim of this study was to assess the effects of photoperiod on male AGR reproduction.*
Materials and Methods*: For this purpose, twenty rats weighing 945 ± 171g were divided into four lots. Each lot was randomly allocated one of the following lighting times: 0h; 12h; 18h or 24h per day. The essay lasted 8 weeks.*
Results*: The main results showed that the weight of testes and vas deferens were significantly (p<0.05) higher in male AGR subjected to less than 18 hours of light per day. Regarding the caudal epididymal sperm count, a similar trend, i.e. a gradual increase was observed with decreasing photoperiod, although without any significant difference (P>0.05). On the other hand, the reduction in the duration of exposure to light did not significantly affect (p>0.05) the serum testosterone concentration and the reaction time of the male to the presence of a female.*
Conclusion: *A 12-hour photoperiod is not detrimental to male AGR fertility.*
Key Word*: African giant rat, male, fertility, Photoperiod, captivity*.

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I. Introduction

Populations of sub-Sahelian countries have a fairly diverse wildlife animal that can be used as meat.[1,2] However, in view of population growth and the pressure exerted on wildlife, several species of rodents could disappear, if nothing is done urgently.[3, 4] This is the case of the African giant rat (AGR)[5], also called cricetoma (Cricetomysgambianus). In fact, the quantities taken by hunting decrease year after year, reflecting its rarity in the wild.The breeding of AGR appears to be a solution for its preservation in the wild and therefore for a sustainable supply of its meat. Cricetoma farms have existed for several years and do not give satisfactory results when their performances are compared to those in the wild.

The success of AGR production in captivity requires a better definition of its breeding techniques, taking inspiration from its way of life in the wild (feeding, reproduction and housing). Particular attention should be paid to the duration of exposure to light. Indeed, AGR lives in burrows and other dark dwellings during the day and only comes out at night. It is a nocturnal animal.[6, 7] In captivity, it is reared in lighted buildings for up to twelve hours a day. Couldn't this be the cause of their poor performances in captivity?

Photoperiod plays an important role in endocrine function and then in reproduction of animals, both wild and domestic.[8] In short-day species, the low photoperiod increases the synthesis and secretion of reproductive hormones including GnRH (gonadotropin-releasing hormone), FSH (follicle-stimulating hormone) and LH (luteinizing hormone).[9, 10] In Sprague-Dawley rat, Olayaki et al.[11]observed that lowering the photoperiod reduces testicular weight, sperm mobility, viability and count in the semen. On the other hand, Ali et al.[10] recorded a decrease in testicular weight and serum testosterone concentration in AGR continuously exposed to light. What would be the fertility of the male AGR if its environment in captivity was close to that in the wild? Else, could their poor performances in captivity be due to the too long photoperiod (12h/24) in livestock buildings? The aim of the present study was toanswer these questions, and the answers could be an important contribution to the success of cricetoma breeding in captivity.

II. Material And Methods

Site and period of study

This study was conducted at the Teaching and Research Farm of the University of Dschang between August and October 2019. The farm is located in the highlands of West Cameroon (latitude 5 - 7 N, longitude 8 - 12 E). The climatic factors such as rainfall, temperature and humidity are 2000 mm, 16 - 17 °C and 49 - 97% respectively. The natural photoperiod there is 12 hours a day.

Animals and housing

Twenty male AGR weighing 945 g ± 171 g were randomly divided into four groups. To each lot was assigned one of the following light treatments chosen at random: 0 h, 12 h, 18 h and 24 h of light/day. Each rat was reared in one of the individual lodges built with reinforced concrete and closed with a metal door.

Feeding

Animals were fed a standard food for laboratory rat and received in addition sweet potato and ripe banana.

Data collection and studied parameters.

Reaction time

The libido in this study was assessed by the reaction time that was the time taken by a male to react to the presence of a female.Forty-eight hours before the sacrifice, an adult female was transferred into a male cage. As soon as the couple was formed, the chronometer was started and stopped when one reaction caused by the presence of a female was observed. Once the stopwatch was stopped, the time obtained was taken as the reaction time. The maximum observation time was 5 minutes.

Weight of reproductive organs

After the sacrifice, the testis, epididymis, vas deferens and accessory glands were weighed using an electronic balance with a capacity of 160 g and a sensitivity of 0.01 g.

Serum testosterone concentration

Serum testosterone level was assessed using the ELISA kit (DRG Products). The assay was carried out by the immune enzymatic solid phase method as described the explanatory note of the commercial kit. Testosterone concentrations were determined by projecting optical densities onto the calibration curve.

Characteristics of epididymal sperm

Once the animal was sacrificed, epididymis tails of each rat were removed, weighed and dilacerated in a petri dish containing 10 ml of 0.9% NaCl solution. The latter was previously incubated in a water bath at 37°C. The resulting solution was used for the evaluation of sperm mobility, viability and count using the Sperm Quality Analysis System.

Histology of the testis

Once the testes were removed, they were stored in 10% formalin for fixation. Then, the testicle was dehydrated in ethanolic alcohol of increasing concentration (50 - 100%) before the hardening in paraffin. The 5 µm sections were made with a microtome, stained, and observed under an optical microscope at 100 magnification.

Statistical analysis

One-way ANOVA was used to appreciate the effects of photoperiod on the reproductive parameters of male AGR. Duncan's test has served to separate means when significant differences existed. Significant threshold was fixed at 0.05 and the results were expressed as means ± standard deviation. SPSS 20.0 was used to perform the analysis.

III. Result

Reaction time and serum testosterone level

It appears from figure 1 that the reaction time in male AGR increased insignificantly ($p>0.05$) with the decrease in lighting duration. On the other hand, the serum testosterone level fell insignificantly ($p>0.05$) when the photoperiod decreased (figure 2).

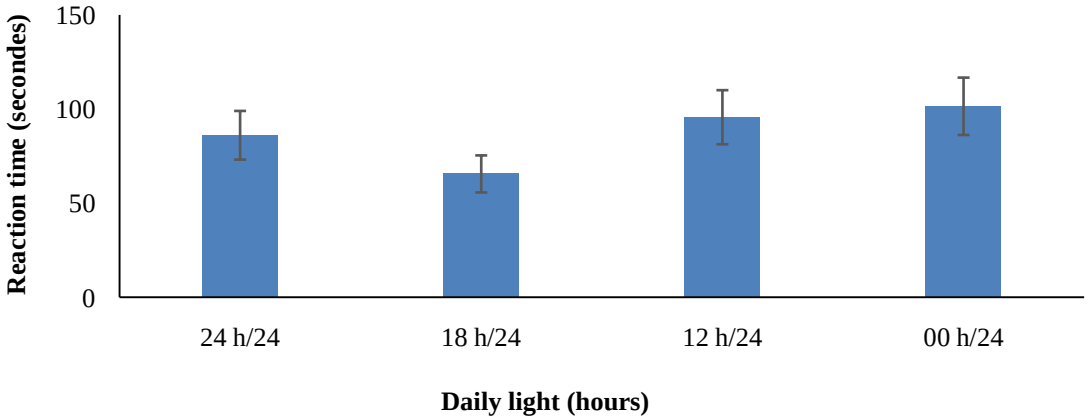


Figure 1: Effect of photoperiod on the reaction time in African giant rat

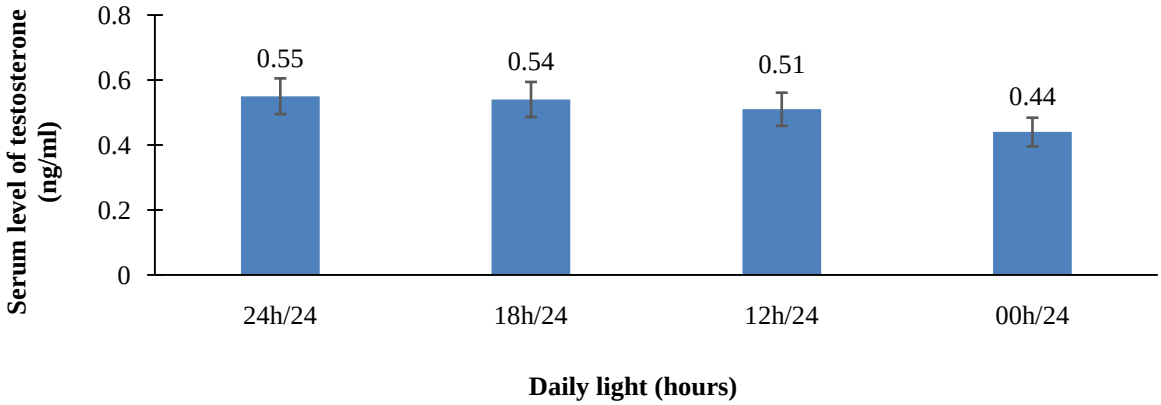


Figure 2: Effect of photoperiod on serum level of testosterone in male African giant rat

Weight of reproductive organs

The weights of the testes and vas deferens increased significantly ($p<0.05$) with the decrease in the lighting duration (table 1). As for other reproductive organs, their weight varied in a non-significant manner and independently ($p>0.05$) to the photoperiod.

Table 1: Effect of photoperiod on the weights of genital organs

Poids (g)	**Daily light (hours/day)**				
	24	18	12	00	p
Testis	7.46 ± 0.41^{ab}	6.28 ± 1.05^{b}	7.90 ± 0.87^{a}	8.01 ± 0.05^{a}	0.04
Epididymis	2.68 ± 0.11	2.41 ± 0.53	2.89 ± 0.58	2.54 ± 0.35	0.47
Vas deferens	0.35 ± 0.07^{b}	0.46 ± 0.05^{ab}	0.54 ± 0.15^{a}	0.55 ± 0.01^{a}	0.05
Prostate andseminalvesicles	11.73 ± 0.67	10.20 ± 0.46	11.79 ± 2.44	11.37 ± 1.20	0.47

(a, b, c): Inside the line, numbers with the same letter are not significantly different between groups ($p>0.05$); p : Probability

Characteristics of epididymal sperm

The percentage of sperm showing a very fast motility did not change depending on the lighting treatment, despite a significantly ($p<0.05$) higher rate recorded in animals enlightened 12 hours a day compared to other treatments (Table 2). The number of sperm per cauda epididymis increased with decreasing photoperiod. This increase, although not significant ($p>0.05$) reached 21.75% between males exposed daily to 24 hours of light and those raised permanently in the dark.

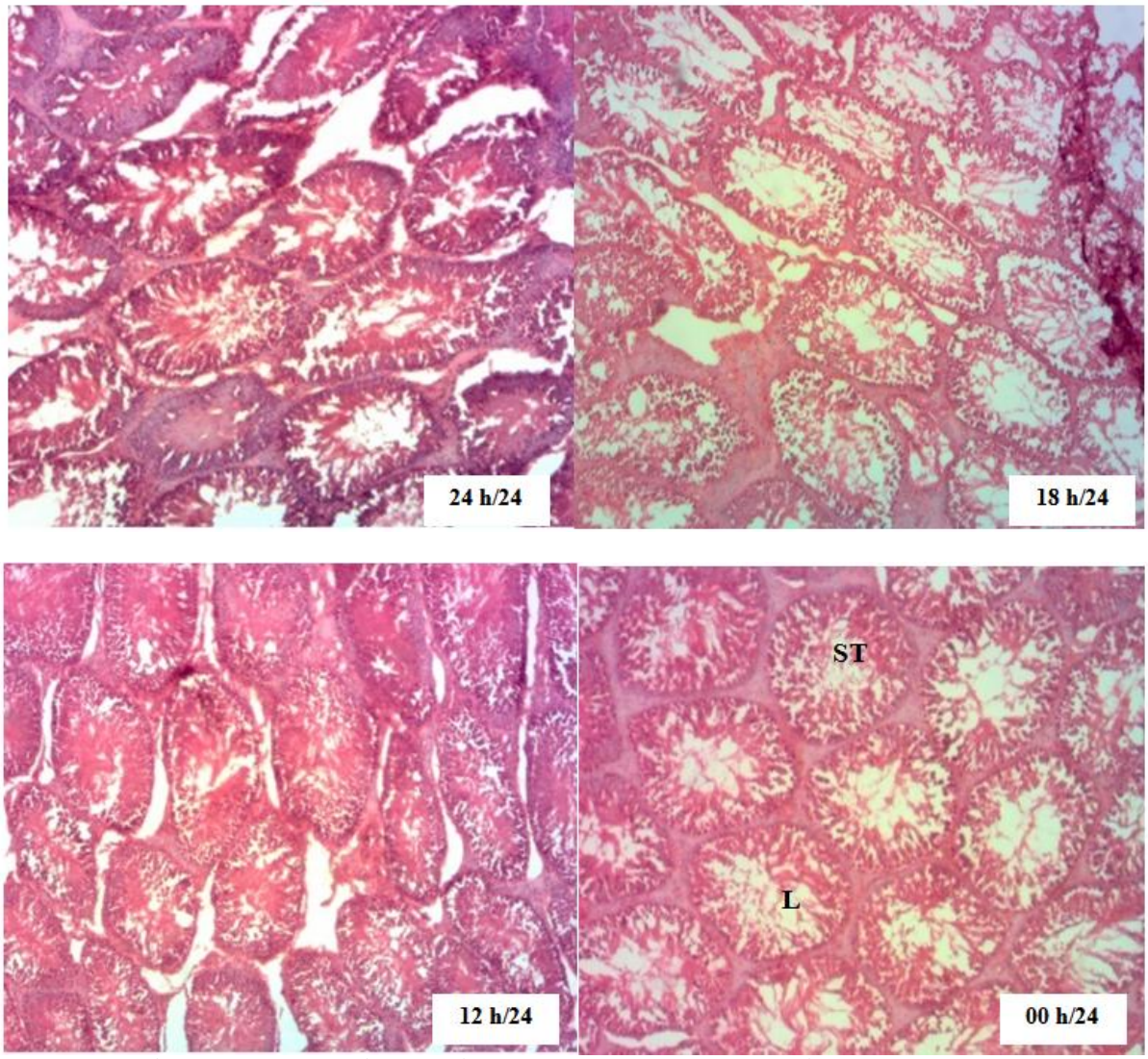
Table 2: Effect of photoperiod on the characteristics of epididymal sperm cells

Cauda epididymal spermcells	**Daily light (hours/Days)**				
	24	18	12	00	P
Number/g cauda epididymis ($x10^6$)	1154.56 ±372.37	1709.29 ±264.98	2006.89 ±534.00	2190.47 ±722.65	0.37
Very fast mobility(%)	32.02 ± 1.33^{bc}	27.79 ± 2.20^{c}	37.25 ± 2.01^{a}	32.57 ± 2.82^{b}	0.00
Tail beatingfrequency (Hz)	3.87± 0.40	3.90± 0.28	4.32± 0.17	3.92± 0.45	0.17

[a,b]: Means having the same letter on the same line are not significantly different (p>0.05).

Histology of testes

In male AGR exposed to darkness as well as those exposed to light, the seminiferous tubules have well-defined and regular architecture. Furthermore, the interstitial space showed no apparent abnormalities whatever the duration of light animals were submitted (figure 3).



ST : normal seminiferous tubule; **L**: lumen of the seminifeous tubule ; **Ei** :interstitial space; Magnification: 100

Figure 3: Effect of photoperiod on testis histological structure in African giant rat

IV. Discussion

The African giant rat (AGR) is a nocturnal animal. This assumes that in captivity 12 hours of light to which it is subjected could be detrimental to its fertility. In the present study, the decrease in photoperiod resulted in a significant (P <0.05) increase in testicular weight. This result is consistent with that of Ali et al. [10] who observed a 17.8% drop in testis weight in continuously illuminated AGR. The weight of the testis depends on that of its constituent elements, among which the seminiferous tubules.[12] The development of the later is stimulated by the gonadotropin FSH and gonadoliberin GnRH whose secretion are in turn under the influence of melatonin. This epiphysis hormone is mostly produced at night. Consequently, the secretion of melatonin is proportional to the length of the night in animals such as small ruminants.[13] Thus, the long durations of the night are favorable to high blood melatonin concentration, and therefore to a great stimulation of the hypothalamic and pituitary endocrine cells. The development of the seminiferous tubules which takes place under the action of FSH becomes stimulated in such circumstances, and could explain the weight of the testis in animals reared in long darkness.[14]

Following the logic used in the previous paragraph, one would have expected Leydig cell development and then blood testosterone concentration to be positively correlated with the development of the testis in animals subjected to a same light treatment. This was not the case, if we look at the blood testosterone level which paradoxically tended to drop with the decrease in the photoperiod. Our results disagree with those of Ali et al.[10] who noted a decrease in serum testosterone concentration in AGR continuously exposed to light.

The libido assessed in the present study by the reaction time of the male is related to the serum testosterone concentration.[14] In this study, the tendency for the male's reaction time to increase in the presence of a female when the photoperiod decreased appeared normal given the decreasing serum testosterone level. Indeed, the reaction time is an indicator of the blood testosterone level. The more testosterone there is in the blood, the faster the male reacts in the presence of a female.

The sperm count in the cauda epididymis increased in AGR submitted to a short photoperiod, although insignificantly. This result would reflect a high concentration of circulating FSH, characteristics of the short photoperiods. It disagrees with that of Olayaki et al.[11]who instead showed that the decrease in the photoperiod reduces the sperm concentration in the Sprague Dawley rat.

The beat of the flagellum of a spermatozoon is an evidence of the active nature of its mobility. This is why the frequency of these beats would be higher in lots of cricetoma with the greatest mobility of sperm.

In the present study, this beating frequency does not appear to be related to the fast motility of the sperm, and this could be explained by the fact that the fast motility is only one component of the sperm motility, and therefore characterizes not all motile sperm.

V. Conclusion

A 12-hour photoperiod is not detrimental to male AGR fertility.

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