Influence of Season and Day Length on Production and Reproductive Traits and Egg Characteristics of the Guinea Fowl (*Numida meleagris*)

Korankye Okyere\(^1\), James Kwame Kagya-Agyemang\(^1\), Serekye Yaw Annor\(^1\), Akwasi Asabere-Ameyaw\(^2\) and Clement Gyeabour Kyere\(^1\)*

\(^1\)Department of Animal Science Education, Faculty of Agriculture Education, University of Education, Winneba, Mampong-Ashanti, Ghana.  
\(^2\)Department of Biology Education, Faculty of Science Education, University of Education, Winneba, Ghana.

Authors’ contributions

This work was carried out in collaboration among all authors. Authors KO, JKK, AAA, SYA and CGK designed the study, wrote the protocol and wrote the first draft of the manuscript. Author SYA performed the statistical analysis and managed the analyses of the study. Authors KO and CGK managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: This study was conducted to determine the influence of season and day length on production traits, egg characteristics, fertility and hatchability of laying Guinea fowls (*Numida meleagris*).

Study Design: Factorial design was used for the study.

Place and Duration of Study: The study was conducted at the Poultry Unit of the Department of Animal Science Education, University of Education, Winneba, Ghana, Mampong campus from September, 2015 to December, 2016.

Methodology: Four (4) hens and one (1) male per replicate and fifteen (15) per treatment were each subjected to 12 hours of artificial light and 12 hours of darkness (12L:12D), 14 hours of artificial light and 10 hours of darkness (14L:10D), 16 hours of artificial light and 8 hours of darkness (16L:8D).
darkness (16L:8D) and 18 hours of artificial light and 6 hours of darkness (18L:6D). Each group was replicated three times and reared in three seasons (Dry-December-March, Major rains-April-July and Minor rains-August-November) in a 3x4 factorial experiment. Data were analyzed using General Linear Model procedure of SAS. 

**Results:** Results showed that egg weight, hen-day egg production and egg mass increased (P= .05) with increasing day length. Similar results were observed for yolk height, yolk weight and albumin height. Most production traits, egg characteristics, fertility and hatchability attained the highest (P= .05) value in the major rainy season. 

**Conclusion:** It was concluded that day length of 14-16 hours is sufficient for improved laying performance and that breeding cycles should be planned to coincide with the major rainy season.

**Keywords:** Seasonal variation; light; fertility; hatchability; egg quality.

1. **INTRODUCTION**

In recent times, poultry industry is being viewed as a provider of a healthy alternative to red meat and other protein sources [1]. Guinea fowl is a promising genetic resource alternative for poultry production in the developed world [2]. In many countries of western Africa, where the bird is ubiquitously distributed, Guinea fowls are the second most important source of meat and eggs after chicken [3]. The importance of Guinea fowl farming includes the abundance of birds in many traditional homes, provision of meat and eggs as source of income to rural farmers, the meat as delicacy to consumers and as a source of quality protein due to its low cholesterol content [4]. The socio-cultural usage of the bird includes funeral celebrations, sacrifices, courtship and marriages among the northern tribes of Ghana [5].

Challenges to commercialization of Guinea fowl have been studied [6,7] and these include challenges in breeding, inadequate feeding and health management, poor housing and environmental influence such as temperature, rainfall and photoperiod, lack of broodiness in Guinea hens and mating behaviour as the males exhibit monogamous tendencies in a colony [8,4]. In spite these earlier studies, the available information about the reproductive performance of Guinea fowls looks scanty. Available data indicate farmers achieve low flock size mainly due to poor hatchability of eggs and high keet mortality rate [5]. Low stock of Guinea fowl has been attributed to the poor hatchability of eggs which results from the inefficiency of the brooder hen. These reasons notwithstanding, the most important reason cited by farmers for the poor hatchability is the fact that Guinea fowls are seasonal breeders and will produce in few months within the year [9,10].

Konlan and Avornyo [10] reported that Guinea fowl lay more eggs with high fertility in wet season than in dry season. Guinea fowl keepers have indicated that eggs laid early in the laying season are more viable than those laid later in the season. Fertility rates have been cited to be 55% and 80% by several authors [11,12] respectively whilst hatchability rates have been reported as 64% and 68% by several authors [13,14].

The aim of this study was to determine the influence of season and day length on production traits, egg characteristics, as well as fertility and hatchability of the indigenous Helmeted Guinea Fowl in the middle area of Ghana.

2. **MATERIALS AND METHODS**

2.1 **Study Area**

The study was conducted at the Poultry Unit of the Department of Animal Science Education, University of Education, Winneba, Mampong campus from September, 2015 to December, 2016. Asante Mampong is the capital town of the Mampong Municipality of the Ashanti Region. Mampong is located 60 km North-East of Kumasi on the Kumasi- Ejura road. The Municipality lies between latitude 07 04” degrees North and longitude 01 24” degrees west with altitude 457.1 m above sea level in the Transitional Zone between the Guinea Savanna Zone of the north and Tropical Rain Forest of the south of Ghana. The climatic condition is wet semi-equatorial type, with a bi-modal rainfall of 1224 mm per annum, temperature range of 22.3°C-30.6°C. Rainfall occurs in April to July (Major Raining Season), August to November (Minor Rainy Season) and December to March (Dry Season) [15].
2.2 Experimental Birds and Design

Twelve (12) males and forty-eight (48) females Pearl Guinea fowls of 34 weeks old selected from a flock at the Research Department were used for the study with an average weight of 1.8 kg and 1.5 kg for females and males, respectively. Four (4) hens and one (1) male per replicate and fifteen (15) per treatment were each subjected to 12 hours of light and 12 hours of darkness (12L:12D), 14 hours of light and 10 hours of darkness (14L:10D), 16 hours of light and 8 hours of darkness (16L:8D) and 18 hours of light and 6 hours of darkness (18L:6D). Each group was replicated three times and reared in three seasons (Dry-December-March, Major Rains-April-July and Minor Rains-August-November) in a 3x4 factorial experimental design.

2.3 Housing, Feeding and Medication

The experiment was carried out in an open system oriented house, located in an east - west direction to avoid solar radiation. The open sides of the house measured 12 m × 8 m and 2.5 m height. The roof was constructed with corrugated iron sheets and the walls were built from cement bricks and wires. A total of twelve (12) experimental cages were used for rearing the birds, each measuring 1.4 m × 1.34 m and housed 5 birds. The floor was concreted, and wood shavings were used as litter for the birds. Removable wooden feeding troughs measuring 0.8 m × 0.04 m × 0.03 m were used for feeding the experimental birds. Soya bean, wheat bran, maize, tuna fish, Russia fish, premix vitamin, oyster shell, Diacalcium phosphate and salt were used to formulate a diet containing 16.5% Crude protein and 2750 Kca/kg Metabolizable energy [4]. Feed and water were offered ad libitum in a removable feeding and water troughs. An LED bulb of 50W was used to supply light at an intensity of 5.8lx. The weather record during the study period is shown in Table 1.

2.4 Data Collection

Eggs were collected daily, identified and stored under a room temperature of 25°C for seven days. This was to imitate the environmental conditions of local farmers. Eggs were cleaned, disinfected by fumigation before setting. Candling was performed on day 18 of incubation after which fertile eggs were transferred from the setter to the hatcher. Fertility and hatchability were recorded.

2.5 Parameters Measured

Daily feed intake was determined by subtracting feed refusals from the amount of feed given in the previous day.

\[ \text{Feed intake (g)} = \text{Feed given} - \text{Feed refusals} \]

Hen-day egg production was determined for the daily egg production.

\[ \text{Hen-Day Egg Production} (\%) = \frac{\text{Total number of eggs collected a day}}{\text{Total number of birds}} \times 100 \]

Egg weight (g) was determined by weighing individual eggs collected daily with the use of A&D Weighing EK-6000i electronic balance.

Feed conversion ratio was determined for daily average feed intake and daily average egg weight.

\[ \text{Feed Conversion Ratio} = \frac{\text{Average Feed Intake}}{\text{Average egg mass}} \]

Egg mass (g) was determined by the product of averages of egg weights and hen-day egg production

\[ \text{Egg Mass} = \text{Average egg weight} \times \text{hen-day egg production} \]

Fertility was calculated on the basis of total fertile eggs and total eggs set by candling.

\[ \% \text{ Fertility} = \frac{\text{Total number of fertile eggs}}{\text{Total number of eggs set}} \times 100 \]

The percentage hatchability was determined by expressing the total number of eggs hatched as a percentage of total number of fertile eggs.

\[ \text{Hatchability} (\%) = \frac{\text{Total number of eggs hatched}}{\text{Total number of fertil eggs}} \times 100 \]

The percent hatch rate is the percentage of total eggs hatched out.

\[ \text{Percent Hatch Rate} = \frac{\text{Total number of eggs hatched out}}{\text{Total number of eggs set in the incubator}} \times 100 \]

The destructive method was applied to measure internal and external egg characteristics. These included yolk weight, albumen weight, yolk height, albumen height, shell weight, shell thickness and Egg diameter [8]. Haugh unit (HU) was calculated using Raymond Haugh’s rating [16]. HU = 100 log (H – 1.7W0.37 + 7.6), where, H = Haugh Unit, H = Albumen height (mm) and W = Egg weight (g).
2.6 Statistical Analysis

Data collected were analyzed using General Linear Model (GLM) procedure of Statistical Analysis System (SAS for Windows, version 7). The means were separated by using the probability of difference (PDIFF) procedure of SAS [17].

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Effect of day length on monthly egg production

Monthly egg production for the study period is shown in Fig. 1. The pattern of egg production was similar for all treatments in all months (Fig. 1). However, egg production was better in 16L:8D and 18L:6D treatments than the others. Generally, egg production increased from January, peaking from March to June and declining from July to December. Egg production levels in September to October were the poorest. It should be noted that egg production peaked in the months of high volumes of rainfall and declined in the months of low environmental temperature (Table 1).

3.1.2 Effect of day length on production and reproductive traits

There was no significant (P > .05) difference in feed intake and feed conversion ratio between day length regimens (Table 2). Egg weight increased with increasing day length obtained difference was significant (P < .05) and peaked at 16L:8D and declined significantly in 18L:6D. Similarly, hen-day egg production increased with an increasing day length (P < .05) and reduced slightly at 18L:6D, whereas egg mass progressively increased (P < .05) with increasing daylength reaching highest at 18L:6D. There was no significant difference (P > .05) between the different day length for percent fertility, hatchability of eggs set and hatchability of fertile eggs (Table 2).

3.1.3 Effect of day length on egg characteristics

Results on the effect of day length on egg characteristics are presented in Table 3. Haugh unit, egg diameter, albumin weight, shell weight and shell thickness were not significantly (P > .05) influenced by day length. Yolk height was significantly influenced by day length (P < .05) and 16L:8D was highest whereas 12L:12D was lowest obtained difference was significant (P < .05). Yolk weight was significantly (P < .05) influenced by day length. Day length of 14L:10D recorded the highest value followed by 18L:6D and the lowest value was recorded by 16L:8D. The value for albumin height was highest in 14L:10D (P < .05) followed by 16L:8D whereas 12L:12D recorded the lowest value.

3.1.4 Effect of season on production and reproductive traits

The influence of season on production traits is recorded in Table 4. The highest (P < .05) value for feed intake was recorded in the minor rainy season and lowest (P < .05) in the dry season. More feed is required during the cold rainy seasons to generate heat in birds to maintain body temperature. Major rainy season showed significantly (P < .05) higher egg mass than minor rainy season and dry seasons, respectively. Fertility was significantly (P < .05) influenced by season (Table 4). Hatchability of total egg set was found to be highest (P < .05) in major rainy season and lowest in the minor seasons.

Table 1. Weather records during the study period for the Municipality

| Variables          | Jan | Feb | Mar | April | May | June | July | Aug | Sept | Oct | Nov | Dec |
|--------------------|-----|-----|-----|-------|-----|------|------|-----|------|-----|-----|-----|
| Temperature (°C)   | 33  | 33  | 32  | 31    | 31  | 28   | 27   | 27  | 28   | 29  | 31  | 32  |
| Rainfall (mm)      | 8.4 | 16.3| 175.2|127.9 |103.3|160.6|73.0  |89.2 |222.4 |107.9|42  |16.2 |
| Humidity (%)       | 50  | 60  | 77  | 80    | 80  | 86   | 86   | 86  | 89   | 87  | 78  | 67  |
| Cloud cover (%)    | 28  | 36  | 47  | 51    | 56  | 77   | 81   | 83  | 89   | 69  | 53  | 38  |
| Sun Hours (hrs)    | 115 | 106 | 112 | 104   | 106 | 66.3 | 53.5 | 50.0| 54.5 | 59.3| 82.3| 93.5|

Source: World Weather Online (2016)
Table 2. Effect of day length on production and reproductive traits

| Parameters                        | T0 (12L:12D) | T1 (14L:10D) | T2 (16L:8D) | T3 (18L:6D) | Standard error | P-value |
|-----------------------------------|---------------|--------------|-------------|-------------|----------------|---------|
| **Production traits**             |               |              |             |             |                |         |
| Feed intake (g)                   | 97.92         | 93.72        | 98.37       | 96.21       | 3.16           | 0.72    |
| Egg weight (g)                    | 40.88<sup>c</sup> | 42.12<sup>b</sup>c | 43.21<sup>a</sup> | 41.92<sup>b</sup> | 0.33           | 0.01    |
| Hen-day egg production (%)        | 13.98<sup>d</sup> | 15.55<sup>c</sup> | 18.33<sup>a</sup> | 17.59<sup>b</sup> | 0.33           | 0.01    |
| Egg mass (g/bird/day)             | 14.45<sup>d</sup> | 16.70<sup>c</sup> | 18.41<sup>b</sup> | 21.30<sup>a</sup> | 1.22           | 0.01    |
| Feed conversion ratio             | 2.40          | 2.22         | 2.27        | 2.29        | 0.08           | 0.47    |
| **Reproduction traits**           |               |              |             |             |                |         |
| Fertility (%)                     | 74.1          | 78.7         | 74.9        | 73.7        | 11.85          | 0.80    |
| Hatchability of egg set (%)       | 54.1          | 57.2         | 63.6        | 60.5        | 5.72           | 0.39    |
| Hatchability of fertile eggs (%)  | 74.9          | 76.5         | 79.3        | 81.5        | 4.74           | 0.53    |

<sup>abcd</sup> Means bearing different superscripts in the same row are different at p<0.05, p = probability of main effects, L = light, D = darkness

Table 3. Effect of day length on egg characteristics

| Parameters                   | T0 (12L:12D) | T1 (14L:10D) | T2 (16L:8D) | T3 (18L:6D) | Standard error | P-value |
|------------------------------|--------------|--------------|-------------|-------------|----------------|---------|
| Haugh unit                   | 75.46        | 82.50        | 81.89       | 81.31       | 2.17           | 0.10    |
| Egg diameter (mm)            | 3.95         | 3.99         | 4.02        | 4.01        | 0.05           | 0.72    |
| Yolk height (cm)             | 2.08<sup>d</sup> | 2.21<sup>c</sup> | 2.43<sup>a</sup> | 2.37<sup>b</sup> | 0.05           | 0.01    |
| Yolk weight (g)              | 16.62<sup>c</sup> | 17.32<sup>a</sup> | 16.40<sup>d</sup> | 16.83<sup>b</sup> | 0.20           | 0.02    |
| Albumin height (cm)          | 2.35<sup>d</sup> | 2.65<sup>a</sup> | 2.57<sup>b</sup> | 2.48<sup>c</sup> | 0.04           | 0.01    |
| Albumin weight (g)           | 19.52        | 20.64        | 21.33       | 20.66       | 0.58           | 0.19    |
| Shell weight (g)             | 8.90         | 9.76         | 9.01        | 9.35        | 0.47           | 0.56    |
| Shell thickness (mm)         | 0.19         | 0.11         | 0.09        | 0.09        | 0.05           | 0.40    |

<sup>abcd</sup> Means bearing different superscripts in the same row are different at p<0.05, p = probability of main effects, L = light, D = darkness
### Table 4. Effect of Season on production and reproductive traits

| Parameters                  | December-March (Dry season) | April-July (Major rainy season) | August-November (Minor rainy season) | Standard error | P-value |
|-----------------------------|-----------------------------|---------------------------------|--------------------------------------|----------------|---------|
| **Production traits**       |                             |                                 |                                      |                |         |
| Feed intake (g/day)         | 90.64<sup>c</sup>           | 98.10<sup>b</sup>                | 100.93<sup>a</sup>                   | 2.73           | 0.03    |
| Feed conversion ratio       | 2.24                        | 2.26                             | 2.38                                 | 0.07           | 0.28    |
| Egg weight (g)              | 40.41<sup>c</sup>           | 43.40<sup>a</sup>                | 42.29<sup>b</sup>                    | 0.29           | 0.01    |
| Hen day (%)                 | 17.01<sup>b</sup>           | 28.05<sup>a</sup>                | 4.02<sup>c</sup>                     | 0.29           | 0.01    |
| Egg mass (g/bird/day)       | 15.88<sup>c</sup>           | 21.43<sup>a</sup>                | 19.56<sup>b</sup>                    | 1.04           | 0.01    |
| **Reproduction traits**     |                             |                                 |                                      |                |         |
| Fertility (%)               | 76.1<sup>a</sup>            | 85.1<sup>a</sup>                 | 64.8<sup>c</sup>                     | 3.30           | 0.01    |
| Hatchability of egg set (%) | 57.5<sup>b</sup>            | 69.1<sup>a</sup>                 | 50.0<sup>c</sup>                     | 3.84           | 0.01    |
| Hatchability of fertile eggs (%) | 76.7              | 81.2                             | 76.2                                 | 4.07           | 0.40    |

Means bearing different superscripts in the same row are different at p<0.05, p = probability of main effects

### Table 5. Effect of season on egg characteristics

| Parameters                  | December-March (Dry season) | April-July (Major rainy season) | August-November (Minor rainy season) | Standard error | P-value |
|-----------------------------|-----------------------------|---------------------------------|--------------------------------------|----------------|---------|
| Haugh Unit                  | 78.76                       | 80.67                           | 81.42                                | 1.87           | 0.59    |
| Egg Diameter (mm)           | 3.87<sup>b</sup>            | 4.06<sup>a</sup>                | 4.03<sup>a</sup>                     | 0.04           | 0.01    |
| Yolk height (cm)            | 2.17<sup>c</sup>            | 2.38<sup>a</sup>                | 2.26<sup>b</sup>                     | 0.04           | 0.01    |
| Yolk weight (g)             | 16.39<sup>c</sup>           | 17.05<sup>a</sup>               | 16.62<sup>b</sup>                    | 0.17           | 0.03    |
| Albumin height (cm)         | 2.35<sup>c</sup>            | 2.64<sup>a</sup>                | 2.54<sup>b</sup>                     | 0.04           | 0.01    |
| Albumin weight (g)          | 20.17                       | 21.20                           | 20.23                                | 0.50           | 0.28    |
| Egg shell weight (g)        | 8.57                        | 9.74                            | 9.45                                 | 0.40           | 0.13    |
| Egg shell thickness (mm)    | 0.08                        | 0.17                            | 0.11                                 | 0.40           | 0.23    |

Means bearing different superscripts in the same row are different at p<0.05, p = probability of main effects

### 3.1.5 Effect of season on egg characteristics

Results revealed that seasons resulted in significant (P<.05) influence on egg diameter, yolk height, yolk weight and albumin height (Table 5), whereas, Haugh unit, albumin weight, shell weight and shell thickness were not significantly (P>.05) influenced by season.

### 3.2 Discussion

#### 3.2.1 Effect of day length on monthly egg production

These observations are supported by the study of Ayorinde and Ayeni [18] who reported that the average number of eggs collected increased from dry hot season to the rainy season. The report indicated that more eggs were collected during the month of June, July and August where rainfall peaked. This result is similar to the study of Eleroglu et al. [19] who reported that Guinea fowl egg laying continues all year around in free range and contrasts to Fani et al. [20] who reported that Guinea fowl egg production is confined to the rainy season from April to October in Nigeria. The trends of egg production in this study is supported by Chukwu et al. [21] who reported 150-160 eggs per hen for production season from July to March and values were higher than the report of Konlan et al. [22] who recorded 100 eggs per hen within the same period of study. This report indicates that increased rainfall showed an increased monthly egg output as earlier reported [23].

#### 3.2.2 Effect of day length on production and reproductive traits

These trends obtained in this study are supported by earlier report that long photoperiods stimulate the sexual function of layers and increase egg production and egg mass which is a factor of reproductive performance [23]. According to [24] day length of 10.5-12.75 hours is sufficient for stimulating oviposition and daylength of 12.75-15.25 hours provides maximum production. Fertility and hatchability values were similar to those reported.
earlier [11,20]. Egg weights were better than earlier reports of 38 g, [19,12], 39.99 g [22] and were similar to 40-45 g [20]. This contradicts the earlier findings of Boon, et al. (1997) who attributed increased feed intake in birds as a result of photoperiod differences, as longer photoperiod determines the periods in which birds’ daily activities and feeding can occur and has major effect on feed intake.

3.2.3 Effect of day length on egg characteristics

These trends of egg quality were supported by earlier report of Hesham [25] whose study revealed that birds reared under 16hrs day length laid eggs with significant higher external and internal quality traits. Earlier reports indicate that both evening feeding and extended photoperiod can impact feed efficiency [26,27]. This has the potential to improve metabolism of essential nutrients, especially, calcium and phosphorus for the making of eggs. Increasing day length has been observed to induce photo stimulation (Slope, 1994) and increase in follicle stimulating hormone, luteinizing hormone and oestrogen production. Theses hormones are involved in yolk formation, yolk weight and determines albumen weight and height of eggs laid [23].

3.2.4 Effect of season on production and reproductive traits

This is supported by earlier report that the environmental effect of seasons of high ambient temperature is potential factor to reduce feed intake by 20% [28]. The tolerable temperature for the layer was 15-27°C. According to Oarad et al. [29] stated that higher temperature reduced the production performance of layer hens. Short and long heat exposure caused significant hyperthermia and reduction of egg production, egg weight, ovarian weight and the number of large follicles [30].

This result is supported by earlier findings that high temperature (above 27°C) affects feed consumption, egg weight and eggshell thickness while relative humidity has less impact on egg production, egg weight and feed consumption [31,32]. The decrease in voluntary feed intake during hot seasons is attributed to physiological response to heat stress, aimed at reducing excessive endogenous heat generated in the body due to feed metabolism [33]. It was observed that major rainy season recorded significantly higher values of egg weight followed by minor rainy season and lowest in the dry season. Egg weight was similar to those recorded by Konlan et al. [22] in Northern Ghana and [6] in Botswana. Sloan and Harms [31] have shown that oestrogen and progesterone levels positively correlated with hen-day egg production in pearl Guinea fowls during major rainy seasons in the tropics.

Higher temperatures during the rapid yolk development period increase egg mass [14]. Since egg production is a costly procedure, birds can use more resources to create heavier eggs during higher temperatures instead of using the energy to balance low internal body temperature [34]. Heavier eggs could be a result of increased food availability or lower thermoregulation requirements [34]. As rainfall also increases food availability, it is likely that increased rainfall prior to laying would increase egg mass.

Significant effect of season on fertility was also reported by several authors [18,26]. This trend is corroborated by earlier report that Guinea fowl hens are capable of laying fertile eggs during the rainy seasons where food abound [22]. Also, male fertility has been reported to decline to about 40% when exposed to a temperature 32°C and semen characteristics and sperm-egg penetration is also affected [25]. Higher hatchability in wet seasons was contrary to the study of Bernacki et al. [3] which reported that duck eggs in winter hatched better than monsoon rainy season in Bangladesh. It has been demonstrated that the optimum environmental conditions (temperature and humidity) are synonymous with incubation temperatures, which determine the efficiency of embryonic development of chicks and there are reports of deleterious effects of heat stress on the incubation of avian embryo [6].

3.2.5 Effect of season on egg characteristics

Rainfall increases pituitary release of gonadotropins luteinizing hormone and follicle stimulating hormone and, therefore, stimulates pre-ovulatory follicular growth [35,36] release of larger yolk which influences yolk weight and height, albumin height and egg diameter [37].

4. CONCLUSION

The findings of this study suggest that Guinea fowl production and reproductive performance is enhanced by increasing day length and therefore, artificial lightening to increase day length to about 14-16 hours can signify increased egg production. Rainfall enhances reproductive endowments of Guinea fowls and that breeding
seasons should be planned to coincide with the major rainy season to benefit the full reproductive potential of the bird.

ETHICAL APPROVAL

Experimental protocols used in this study strictly conformed with the internationally accepted standard ethical guidelines for laboratory animal use and care as described in the European Community guidelines; EEC Directive 86/609/EEC, of the 24th November 1986 (EEC, 1986).

DATA AVAILABILITY

The data used in this study are available from all authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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