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Research Article

EFFECT OF BREEDER AGE AND SEASONAL CONDITIONS ON FERTILITY, HATCHABILITY, EGG CHARACTERISTICS, AND SPERM QUALITY OF THE LOCAL KONDE CHICKEN (*GALLUS GALLUS DOMESTICUS* L.) IN BURKINA FASO

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ABSTRACT

The conservation and sustainable utilization of local poultry genetic resources are essential for developing poultry farming adapted to the agroecological conditions of sub-Saharan Africa. This study evaluated the effects of breeder age and seasonal temperature conditions on the reproductive performance of the local Konde chicken ecotype in Burkina Faso. A total of 120 hens and 18 roosters, divided into three age groups (8–15, 15–24, and 24–36 months), were reared under intensive conditions. Laying performance, sperm quality, fertility, hatchability, embryonic mortality, and egg morphometric characteristics were assessed. Heat stress was characterized using the temperature-humidity index (THI). Breeder age significantly affected reproductive performance and sperm characteristics ($P < 0.05$). Birds aged 15–24 months showed the best performance, with fertility of 67.50%, hatchability of 80.56%, progressive sperm motility of 77.22%, and sperm concentration of 3.32×10^9 sperm/mL. In contrast, males aged 24–36 months exhibited reduced sperm quality and fertility, accompanied by increased late embryonic mortality. Temperature conditions also significantly influenced reproductive performance. At a THI of 68–74, fertility, hatchability, and embryonic mortality were 68.02%, 79.50%, and 17.32%, respectively. Under severe heat stress (THI 84–88), fertility decreased to 44.33% and hatchability to 65.21%, while early embryonic mortality increased to 45.03%. Hot periods were also associated with reduced sperm motility and concentration and increased dead sperm. These findings demonstrate that heat stress substantially limits the reproductive potential of Konde chickens. Using breeders aged 15–24 months and scheduling breeding during periods of moderate THI could improve reproductive efficiency and contribute to the sustainable conservation of this local chicken.

Keywords: Konde chicken, THI, Heat stress, Fertility, Hatchability, Age, Sperm quality.

INTRODUCTION

Small-scale poultry farming is a main pillar of livestock production in sub-Saharan African countries, contributing significantly to food security, income generation, and rural household resilience (Manyelo *et al*., 2020; Traoré *et al*.,

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2025). In Burkina Faso, local chickens account for more than 90% of the poultry population and provide a significant share of the animal protein supply, while playing major economic, sociocultural, and heritage roles in family farms (Zaré *et al*., 2021; Traoré *et al*., 2025). Thanks to their hardiness, their adaptation to Sahelian agroecological constraints, and their relative disease resistance, local poultry are now recognized as a strategic lever for the development of sustainable poultry farming in the face of the challenges of population growth, food insecurity, and climate change (Manyelo *et al*., 2020; Kpomasse *et al*., 2023). Among the local chicken ecotypes identified in Burkina Faso, the Konde ecotype raised primarily in the Central-East region is of particular interest because of its strong meat-producing qualities, its ability to adapt to traditional farming systems, and its socioeconomic importance to rural communities (Zare *et al*., 2021, 2023). Recent studies on morphological, morphobiometric, and genetic characterization have shown that this ecotype has a well-differentiated phenotypic identity and sufficient genetic diversity to justify its conservation and integration into genetic improvement programs (Zare *et al*., 2022; Houngbo *et al*., 2025). In particular, analyses based on microsatellite markers have revealed a genetic structure specifically to local ecotypes in Burkina Faso, confirming a unique genetic heritage that can support national breeding and conservation strategies (Zare *et al*., 2022).

In fact, the available knowledge focuses primarily on growth performance, morphobiometric parameters, and a few overall reproductive indicators obtained under semi-intensive conditions (Zare *et al*., 2023, 2024). In contrast, while the genetic and morphological characteristics of the Konde chicken are now relatively well documented, its reproductive potential remains insufficiently characterized. Reported average fertility and hatchability rates are approximately 60% and over 80%, respectively, indicating promising reproductive potential but also high variability, suggesting numerous limiting factors that remain poorly identified (Zare *et al*., 2023, 2024). This knowledge gap remains a major obstacle to implementing effective breeding programs and sustainably improving this ecotype's productivity (Zare *et al*., 2024; Houngbo *et al*., 2025). However, in local poultry, reproductive performance results from complex interactions between genetic determinants and environmental factors. Fertility and hatchability are influenced by the physical and internal characteristics of the eggs, the age and physiological condition of the breeders, the male-to-female ratio, feed quality, health status, incubation conditions, and farm management practices (Manyelo *et al*., 2020). In the Sahelian environment, these factors are compounded by climatic constraints, particularly high temperatures and seasonal variations that can affect egg preservation, embryonic viability, and incubation performance (Igbokwe, 2018). Furthermore, several studies have shown that optimizing the sex ratio, rigorously selecting breeding stock, improving parental nutrition, controlling stocking densities, and reducing free-range foraging are technical strategies that can significantly improve fertility and hatchability in local poultry (Mourad *et al*., 1997; Nahimana *et al*., 2017).

Despite this general knowledge, scientific references regarding the specific reproductive parameters of the chicken ecoype Konde remain scarce. The relationships among egg characteristics for incubation, fertility performance, hatch rates, sperm characteristics, and farm management factors have not yet been studied in an integrated manner. This gap hinders the establishment of objective criteria for selecting breeding stock, the development of technical protocols adapted to local farming systems, and the sustainable utilization of this genetic resource. This is all the more concerning because the gradual intensification of poultry farming and the increasing introduction of exotic genotypes heighten the risk of genetic erosion in local populations (Manyelo *et al*., 2020; Kpomasse *et al*., 2023). In this context, thoroughly characterizing the reproductive performance of the local Konde chicken is essential to establish reliable scientific benchmarks that can support national programs for genetic improvement, conservation, and utilization of poultry genetic resources. This study therefore aims to characterize the reproductive performance of this ecotype in Burkina Faso by describing the physical characteristics of hatching eggs, evaluating key fertility parameters, semen characteristics, and hatchability, and analyzing the factors likely to influence these performance metrics.

MATERIALS AND METHODS

This study was conducted at a poultry farm located in the Bonheur-ville neighborhood, in District 7, Sector 31, of the city of Ouagadougou, from September 2023 to February 2025 (Figure 1). The farm is affiliated with the Center for Agricultural Environmental Research and Training (CREAF) in Kamboinsé. It operates an intensive production system.

Rearing Building

The house was subdivided into pens (3 m high, 2.25 m long, and 1.15 m wide) and fully covered by a roof. Each pen housed one experimental repetition group (one rooster and 5 hens). The animals were housed on a floor covered with peanut shell bedding, which was replaced every two weeks, under natural photoperiodic and climatic conditions.

Ethical statement and approval on animal rights

This experimental study was conducted in accordance with animal welfare and use guidelines. This study did not cause any suffering or result in the sacrifice of any animals. The Institutional Committee for the Protection and Use of Animals approved the experimental procedures in accordance with the ethical guidelines for animal experimentation issued by the Animal Ethics Committee of Joseph KI-ZERBO University (Ouagadougou, Burkina Faso). The study received ethical approval before commencement under reference number CE-UJKZ/2023–09.

Management of birds

The study included 120 Konde hens and 18 Konde roosters aged 8 to 36 months, selected for phenotypic conformity and the absence of visible pathology or malformations. All chickens were sexually mature at the start of the experiment. All animals were fed to standardize feeding conditions and minimize the influence of nutrition on reproductive-parameter assessment (Table 1). All birds were fed the same diet during the experiment, which had an average nutritional composition of 16% crude protein, 2,700 kcal of metabolizable energy per kilogram, 3.5% calcium, 0.5% available phosphorus, and 0.5% iron sulfate.

Table 1. Chemical composition of the breeder chickens' feed.

	Feed component
Raw materials	**Percentage (%)**
Maize	56.60
Wheat sound	8.54
Soybean meal	10
Cottonseed meal	5
Industrial fish meal	10
Oyster shells	8.4
Salt	0.16
Layer premix	0.25
DL-methionine	0.15
Lysine	0.25
Iron sulfate	0.50
Bicalcium phosphate	0.50
Total	**100**

Experimental design

The birds were divided by age category into three experimental groups, each consisting of 36 hens and 6 roosters: 8–12 months, 13–24 months, and 25–36 months. Each group was subdivided into six lots of 7 chickens (a standardized sex ratio of 6 hens to 1 rooster), housed in separate pens to assess result reproducibility at different stocking densities (Molapo and Kompi, 2015). This stratification allowed separate evaluation of the effect of age on reproductive performance, limited the influence of group composition, and ensured a more reliable comparison of fertility, hatchability, and embryonic mortality rates. Age and season effects on fertility were measured using actual fertility rates, and hatching rates and embryonic mortality rates were assessed during a longitudinal follow-up period (Faye, 2022). The influence of the season was assessed across four seasons: cold dry season (November, December, January, February), hot dry season (March, April, May), hot rainy season (June and July), and cold rainy season (August, September, October).

Climatic Characteristics of the Experimental Farm

The average indicative THI values for each period ranged from 84 to 88 (severe heat stress, hot and dry) during March–April (hot dry season); from 78 to 83 (hot and humid) for the May–July period (hot rainy season); from 74 to 79 (cool and humid) between August and October (cool rainy season); and from 68 to 74 (cooler/drier) for November through February (cool dry season).

Environmental data collection

Mean daily ambient temperature (Ta) and percent relative humidity (RH) have been recorded using a thermo-hygrometer placed in the shed. Data collected were used to assess the intensity of heat stress using the calculated temperature-humidity index (THI) (Mader *et al*., 2010): $THI = 0.8 \times Ta + (RH \times (Ta - 14.3)) / 100 + 46.3$, with Ta: Dry-bulb temperature or ambient (air temperature) measured in Degrees Celsius (°C); RH: Relative Humidity expressed as a whole percentage. The THI index values have been classified according to different levels of thermal discomfort in birds (Elshafaei *et al*., 2020): for a $THI \leq 72$, "absolute comfort"; from 72 to 76, conditions correspond to "mild discomfort" requiring partial environmental control; from 77 to 80, this is a situation of "discomfort" requiring environmental modifications; while from 81 to 84, there is "severe discomfort" requiring several environmental control measures. A $THI \geq 85$ creates "life-threatening conditions."

Collection of Rooster Semen

performed. We collected semen using dorso-abdominal massage, a technique recognized for its effectiveness in obtaining fresh semen from gallinaceous birds (Silva and Moran, 2023). Semen samples were protected from light and stored at 22-25°C during transport to the laboratory, within 20 minutes of collection, for macroscopic and microscopic evaluation according to the methodology of Pimprasert *et al.* (2023). The same person always

performed semen collection to minimize bias while optimizing semen quality and quantity. We took precautions to prevent cross-contamination during collection.

Assessment of Rooster Semen Quality

After collection, ejaculate volume per rooster was determined by immediately and gently drawing the entire volume of fluid into a tuberculin syringe (1 mL). The waves of sperm movement, or bulk motility, were rated on a scale of 1 to 5 (1 = no sperm movement or very slow movement; 5 = very rapid waves and visible swirls) (Pimprasert *et al.,* 2023). It was assessed by placing a small drop of each raw sample on a slide and observing it under a phase-contrast microscope at 100X magnification. Progressive or individual motility of sperm from the diluted semen was assessed by microscopic analysis at 400X magnification on a heated stage (Santiago-Moreno *et al*., 2011). Sperm motility was scored on a scale ranging from 0 (lowest) to 5 (highest), expressed as a percentage (%). Scores of zero (0), one (1), and two (2) corresponded, respectively, to an absence of movement, tail movements but no forward progression of the sperm, and circular movements of the sperm. For scores 3 through a large percentage of sperm exhibited progressive but non-rectilinear movement (3); a large percentage of sperm exhibited rectilinear but not very vigorous movement (4); and a large percentage of sperm exhibited progressive and vigorous rectilinear movement (5) (Santiago-Moreno *et al*., 2011).

The rates of morphological abnormalities and sperm mortality in each sample were measured by assessing the percentage of life, abnormal, and dead sperm (Pimprasert *et al*., 2023). To do this, 10 µL of semen was mixed with 50 µL of eosin-nigrosin stain on a microscope slide to prepare a thin smear. The smear was air-dried for 10 minutes. At least 200 spermatozoa were examined (400X magnification) under a drop of oil immersion, and those exhibiting atypical morphology and pink staining (dead) were counted. Sperm concentration was determined using a Thoma cell hematocytometer. A 10 µL sample of semen was diluted with 390 µL (1:400) of 4% sodium chloride solution. A drop of the diluted semen sample was placed in the chamber of the hemocytometer, and the count was performed using a compound microscope (400X magnification). The sperm concentration was calculated and expressed in billions (10^9) of sperm per mL, following the methodology described by Authaida *et al.* (2023).

Egg Collection and Characteristics

Egg Incubation

The eggs were collected daily, identified by batch, disinfected, stored at 15 °C, and then incubated in batches of 150 to accurately determine fertilization and hatch rates. Incubation was carried out using an automatic egg-turning incubator (the eggs were turned at 45°), at an average temperature of 37.8 °C, with relative humidity between 60% and 75%. Two candling procedures were performed on days 7 and 14 of incubation to identify clear eggs (unfertilized) and embryonic mortality. After 18 days of incubation, the eggs were transferred to a hatcher at 37°C and 90% relative humidity (Sanfo *et al*., 2017). At the end of the 21-day incubation period, unhatched eggs were systematically candled to detect late embryonic mortality. Fertility rates were calculated by dividing the number of fertilized eggs by the total number of eggs placed in incubation (Alam *et al.,* 2024).

Measured Parameters

Fertility assessment is based on the fertilization rate, defined as the ratio of fertilized eggs to the total number of eggs placed in incubation (Alam *et al*., 2024). In addition, the hatching rate, egg weight, and duration of reproductive cycles were monitored in each batch (Kouadio *et al*., 2014; Sanfo *et al*., 2017). Finally, embryonic mortality and chick weight at hatching were systematically recorded to establish precise correlations between egg-laying quality and offspring viability (Sanfo *et al*., 2017). Finally, embryo mortality rates calculated as the ratio of unhatched eggs containing dead embryos to the total number of fertile eggs placed in incubationwill help refine the diagnosis of potential causes of reproductive failure (Alam *et al.,* 2024; Zaré *et al*., 2024). The following formulas were used to calculate the measured parameters:

Overall laying rates and individuals laying rates

Laying rate = (number of eggs laid × 100) / (laying duration per layer)

Individual laying rate = (number of eggs laid per bird) / (laying duration per bird) × 100

- **The actual fertility and hatch rates were calculated using the following formulas**:

  Fertility rate (FR) = (number of fertile eggs) / (number of incubated eggs) *100
  Hatching rate (HR) = (number of hatched eggs) / (number of fertile eggs) * 100
- **Embryonic mortality rates were calculated using the following formulas:**

Early embryonic mortality rate (EEMR) = (number of dead embryos on day 15) / (total number of fertilized eggs) * 100

Late embryonic mortality rate (LEMR) = (number of eggs with dead embryos on day 21) / (total number of fertilized eggs) * 100

The average egg shape index (ASI) is used to measure the mechanical strength of the shell and is calculated as follows:

Egg index = length / width × 100

Percentage of clear eggs = (number of clear eggs) / (total number of eggs placed in incubation) × 100

Average egg weight = (total weight of eggs) / (number of eggs)

Average number of eggs per hen per year = (total number of eggs laid by all hens per year) / (total number of hens)

Data Processing and Statistical Analysis

The collected data were processed and expressed as mean ± standard deviation. Statistical analyses were performed using GraphPad Prism software, with an analysis of variance (ANOVA) to compare the means of the reproductive parameters among the different experimental groups. For significant differences between groups, Tukey's multiple comparison test was used at a 5% significance level.

RESULTS AND DISCUSSION

The age of the breeding stock significantly influenced reproductive performance ($P < 0.05$). Egg production rates: The average number of eggs (ANE) increased with age, rising from 85.50 ± 6.30 to 93.25 ± 5.20 eggs per hen for the 8–15-month and 24–36-month age groups, respectively, based on a flock of 120 laying hens. Hens aged 15 to 24 months exhibited the best reproductive performance, with the highest fertility (67.50%) and hatch rates (80.56%), as well as a low early embryonic mortality rate (23.02%). In contrast, breeders aged 24–36 months had the highest late embryonic mortality rates (18.38%) and reduced fertility (44.36%), indicating a decline in reproductive efficiency with aging (Table 2).

Table 2. Effect of age on the reproductive performance of local Konde ecotype hens.

Parameters	**Age of breeding chickens (months)**				
	[8 – 15]	**[15 – 24]**	**[24 – 36]**	**Global**	**P-value**
ALR (%)	42.72**a**	44.53**a**	37.53**b**	40.30	0.04
ANE	85.50 ± 6.30**b**	91.61 ± 8.70**a**	93.25 ± 5.20**a**	89.33 ± 3.21	0.04
ALI	13 ± 2**b**	17 ± 3**a**	15 ± 3**a**	14 ± 5	0.03
EEMR (%)	32.50**a**	23.02**b**	31.03**a**	27.12	0.01
LEMR (%)	8.45**c**	13.33**b**	18.38**a**	14.32	0.02
BER (%)	45.83**a**	30.72**b**	41.17**a**	35.70	0.04
FR (%)	52.33**b**	67.50**a**	44.36**c**	61.39	0.03
HR (%)	67.60**c**	80.56**a**	72.81**b**	73.32	0.04

ANE: Average Number of Eggs; ALI: Average Laying Interval; ALR: Average Laying Rate; AEH: Average Eggs per Hen; EEMR: Early Embryo Mortality Rate; LEMR: Late Embryo Mortality Rate; HR: Hatching Rate; FR: Fertility Rate; BER: Blank Egg Rate;

a, b, c: Different letters within the same row indicate significant differences ($p < 0.05$)

Age significantly affected all sperm parameters evaluated in local roosters of the Konde ecotype (Table 3). Roosters aged 15 to less than 24 months showed the best performance in terms of total motility (3.33 ± 0.71%), progressive motility (77.22 ± 10.64%), and ejaculate volume (0.33 ± 0.08 mL), as well as the highest sperm concentration (3.32 ± 0.72 × 10^9 sperm/mL). Conversely, roosters aged from 24 to 36 months had the highest values for dead sperm (21.98 ± 4.65%) and sperm abnormalities (19.33 ± 2.78%).

Table 3. Effect of age on sperm parameters in local roosters of the Konde ecotype.

Sperm parameters	**Age of breeder chickens (months)**				
	[8 – 15[	**[15 – 24[**	**[24 – 36[**	**Global**	**P-value**
Motility Mass (count)	2.44 ± 0.53**b**	3,33 ± 0,71**a**	2,66 ± 0,50**b**	2,81 ± 0,58	0,0099
Progressive Motility (%)	58.89 ± 6.97**c**	77,22 ± 10,64**a**	63,88 ± 7,41**b**	66,66 ± 8,34	0,0003

Volume (ml)	0.23 ± 0.05**b**	0,33 ± 0,08**a**	0,18 ± 0,07**c**	0,25 ± 0,07	<0,001
Dead Sperm Rate (%)	13.11 ± 3.37**c**	16,88 ± 2,89**b**	21,88 ± 4,65**a**	17,29 ± 3,64	0,003
Abnormalities rate (%)	10.22 ± 2.22**c**	14,11 ± 3,48**b**	19,33 ± 2,78**a**	14,55 ± 2,83	0,001
Concentration (.10^9spz/ml)	2.57 ± 0.57**b**	3,32 ± 0,72**a**	1,63 ± 0,44**c**	2,51 ± 0,58	<0,0001

a, b, c: Different letters within the same row indicate significant differences ($p < 0.05$)

The season significantly affected the reproductive performance of local hens ($P < 0.05$) (Table 4). The cold dry season recorded the highest average laying rate (46.50%), followed by the cold rainy season (42.52%), while the hot dry season (33.31%) and hot rainy season (31.02%) showed the lowest performance. The best reproductive results were obtained during the cool seasons, with the highest fertility (68.02% and 65.33%) and hatch rates (79.50% and 80.08%) and the lowest rates of early embryonic mortality (22.12% and 27.23%). In contrast, the hot dry season showed the lowest performance, with the highest levels of embryonic mortality (EEMR = 45.03%; LEMR = 25.08%) and clear eggs (46.82%), reflecting the adverse effect of heat stress on reproductive performance.

Table 4. Effect of the season on the reproductive performance of local Konde ecotype hens.

Breeding Parameters	**Data Collection Season**				
	Cold dry season	**Hot dry season**	**Hot rainy season**	**Cold rainy season**	**P-value**
ALR (%)	46.50**a**	33.31**b**	31.02**b**	42.52**a**	0.04
ANE (number)	15.00 ± 2.00**a**	11.00 ± 3.00**b**	11.40 ± 1.50**b**	13.35 ± 2.21**c**	0.03
ALI (days)	13.02 ± 1.02**b**	18.31 ± 1.10**a**	16.10 ± 1.20**a**	11.20 ± 0.39**a**	0.02
EEMR (%)	22.12**d**	45.03**a**	33.45**b**	27.23**c**	0.03
LEMR (%)	17.32**b**	25.08**a**	23.03**a**	19.01**b**	0.04
BER (%)	35.05	46.82	44.05	33.52	0.06
FR (%)	68.02**a**	44.33**c**	50.33**b**	65.33**a**	0.02
HR (%)	79.50**a**	65.21**c**	70.01**b**	80.08**a**	0.04

ANE: Average Number of Eggs; ALI: Average Laying Interval; ALR: Average Laying Rate; AEH: Average Eggs per Hen; EEMR: Early Embryo Mortality Rate; LEMR: Late Embryo Mortality Rate; HR: Hatching Rate; FR: Fertility Rate; BER: Blank Egg Rate;

a, b, c: Different letters within the same row indicate significant differences ($p < 0.05$)

The collection season significantly affected total motility, progressive motility, the percentage of dead sperm, and sperm concentration ($P < 0.05$), but not ejaculate volume or the rate of sperm abnormalities ($P > 0.05$) (Table 5). The highest values for total motility (3.22 ± 0.66%), progressive motility (73.33%), and sperm concentration (2.33 ± 0.77 × 10^9 sperm/mL) were recorded during the cold dry season. Concentration was also high during the cold rainy season (2.57 ± 0.79 × 10^9 sperm/mL). In contrast, the lowest values for total motility (2.00 ± 0.87%), progressive motility (57.22%), and sperm concentration (1.61 ± 0.54 × 10^9 sperm/mL) were observed during the hot dry season. The percentage of dead sperm was significantly higher during the hot dry and hot rainy seasons (23.88% and 24.11%, respectively) than during the cold dry and cold rainy seasons (18.11% and 19.44%, respectively).

Table 5. Effect of the season on sperm parameters of local Konde ecotype roosters.

Sperm parameters	**Data Collection Season**				
	Cold dry season	**Hot dry season**	**Hot rainy season**	**Cold rainy season**	**P-value**
Motility Mass (count)	3.22 ± 0.66**a**	2.00 ± 0.87**c**	2.44 ± 0.53**b**	2.66±1.00**b**	0.020
Progressive Motility (%)	73.33 ± 11.18**a**	57.22 ± 7.55**c**	63.33 ± 7.50**b**	65.55 ± 9.17**b**	0.0039
Volume (ml)	0.23 ± 0.13	0.15 ± 0.07	0.20 ± 0.09	0.25 ± 0.09	0.127
Dead Sperm Rate	18.11 ± 3.55**a**	23.88 ± 2.96**b**	24.11 ± 4.02**b**	19.44 ± 3.53**a**	0.017

(%)					
Abnormalities rate (%)	13.44 ± 3.94	17.22 ± 3.80	14.77 ± 4.02	17.01 ± 3.53	0.121
Concentration (.10^9spz/ml)	2.33 ± 0.77**a**	1.61±0.54**b**	1.83 ± 0.57**b**	2.57 ± 0.79**a**	0.0067

a, b, c: Different letters within the same row indicate significant differences ($p < 0.05$)

Effect of the Laying Hen's Age on Egg Characteristics

The age of the laying hens significantly influenced egg weight and length ($P < 0.05$), while its effect on the width remained nonsignificant ($P = 0.06$) (Table 6). The average egg weight increased from 36.37 ± 3.06 g in hens aged 8–15 months to 42.52 ± 4.15 g in those aged 24–36 months. A similar trend was observed for egg length, which increased from 47.27 ± 1.45 mm to 51.23 ± 3.60 mm. In contrast, the shape index remained relatively stable (79.14–81.30%), suggesting that the increase in egg size with age occurred proportionally.

Table 6. Effect of seasons and age on egg characteristics of local Konde ecotype hens.

Parameters	**Age of breeding chickens (months)**				
	[8 – 15[	**[15 – 24[**	**[24 – 36[**	**Global**	**P-value**
Egg weight (g)	36.37 ± 3.06**c**	39.72 ± 3.10**b**	42.52 ± 4.15**a**	40.60 ± 3.35	0.03
Egg length (mm)	47.27 ± 1.45**b**	50.67 ± 3.08**a**	51.23 ± 3.60**a**	50.75 ± 2.07	0.04
Egg width (mm)	38.11 ± 3.31	40.10 ± 3.98	41.65 ± 3.78	39.41 ± 1.30	0.06
ESI (%)	80.63	79.14	81.30	80.66	0.08

EW: egg weight; EL: egg length; EW: egg width; ESI: egg shape index

a, b, c: Different letters within the same row indicate significant differences ($p < 0.05$)

Season had a significant effect on egg weight, length, width, and shape index ($P < 0.05$). The heaviest eggs were produced during the cold dry and rainy seasons, while the lowest weights were recorded during the hot dry and hot rainy seasons. The shape indices ranged from 72.78% to 78.13% (Table 7).

Table 7. Effect of the season on eggs characteristics of local Konde ecotype hens.

Parameters	**Data Collection Season**				
	Cold dry season	**Hot dry season**	**Hot rainy season**	**Cold rainy season**	**P-value**
Egg weight (g)	42,52 ± 4,15**a**	37,37 ± 3,16**b**	38,71 ± 2,10**b**	42,14 ± 3,84**a**	0,03
Egg length (mm)	52,13 ± 0,55**a**	46,60 ± 2,01**b**	47,11 ± 1,02**b**	49,06 ± 1,03**a**	0,02
Egg width (mm)	37,94 ± 1,17**b**	35,93 ± 1,12**c**	35,67 ± 1,24**c**	38,33 ± 0,95**a**	0,04
ESI (%)	72,78	77,10	75,71	78,13	0,06

PO : Poids ; Lo : Longueur ; La : Largeur ; IF : Indice de Forme

a, b, c : les lettres différentes au sein d'une même ligne indiquent des différences significatives ($p < 0,05$).

The results show that the age of breeding hens is a major determinant of reproductive performance in local hens of the Konde ecotype. The best performance observed in hens aged 15 to 24 months characterized by higher fertility and hatch rates as well as low early embryonic mortality is consistent with current knowledge of avian reproductive physiology. Breeding hens of intermediate age generally exhibit an optimal balance between sexual maturity, ovarian activity, and gamete quality, which promotes fertilization and embryonic development (Tona *et al*., 2001; Tona *et al*., 2004; Alo *et al*., 2024). Conversely, young breeding hens produce eggs that are still not very uniform. At the same time, aging is accompanied by a gradual decline in oocyte quality, a decrease in the viability of sperm stored in the ureterovaginal glands, and a deterioration in shell quality, leading to reduced fertility and hatchability (Kheawkanha *et al*., 2021). These observations are consistent with Alo *et al*. (2024), who reports that eggs from middle-aged breeders generally exhibit the best incubation performance. In contrast, very

young and old hens produce eggs with lower hatching potential. The increase in the average number of eggs and egg weight with age observed in this study also confirms results from commercial breeders and local breeds. Older laying hens produce larger eggs due to the full development of the reproductive system and increased the deposition of yolk and albumen (Ulmer-Franco *et al*., 2010; Traore *et al*., 2025). However, this increase in egg size does not consistently translate into improved hatchability, contrary to the observations of Sanfo *et al*. (2017). Several authors have shown that large eggs from older breeders often exhibit increased intermediate and late embryonic mortality as well as reduced fertility, due in particular to poorer shell quality, increased porosity, and greater water losses during incubation (Agbehadzi *et al*., 2024).

The decrease in fertility observed in hens aged 24 to 36 months is consistent with results reported in broiler breeder flocks, where aging in females is accompanied by a reduction in oocyte quality and decreased efficiency of sperm storage in the tubular glands of the oviduct (Iqbal *et al*., 2014; Kheawkanha *et al*., 2021). This decrease in fertility is generally associated with an increase in clear eggs and higher embryonic mortality, particularly during the final stages of incubation (Agbehadzi *et al*., 2024). The relatively high rates of late embryonic mortality observed in older breeding females may also be explained by changes in the external quality of the eggs. Although egg weight increases with age, shell mechanical strength and gas-exchange properties may decrease (Yenilmez *et al*., 2023), thereby compromising embryonic development. Roque and Soares (1994) demonstrated that shell quality directly influences egg weight loss during incubation, embryonic mortality, and hatch rates, particularly in older breeding females.

Furthermore, the external characteristics of the eggs observed in this study confirm that age primarily improves egg weight and dimensions without significantly altering their morphology. The shape index remained stable (79.14–81.30%), indicating that the simultaneous increase in egg length and width occurred proportionally. This stability in the shape index is consistent with the observations of Manyeula *et al.* (2021), who showed that the age of breeding hens increases eggs weight and dimensions. Conversely, the poor performance observed during the dry and hot season confirms the deleterious effects of heat stress on avian reproduction. High temperatures reduce feed intake, disrupt hormonal secretions, decrease egg weight, and impair shell quality (Oguntunji and Alabi, 2010). They also contribute to increased embryonic mortality and the production of clear eggs (McDaniel *et al.*, 1995). These observations are consistent with experimental studies showing that prolonged heat stress in breeding birds reduce egg weight, diminishes albumen and shell quality, and compromises embryonic development (Wang *et al.*, 2025). The observed seasonal variations in egg weight and dimensions also confirm that cooler seasons promote the production of heavier and longer eggs. Eggs collected during the cold rainy season were the most rounded, while those from the cold dry season were relatively more elongated, suggesting that environmental conditions influence the shape of eggs laid by local hens of the Konde ecotype. This seasonal variation, combined with the increase in egg size with age, highlights the importance of these two factors in shaping egg phenotypic characteristics. Greater nutrient availability, combined with reduced energy expenditure related to thermoregulation, promotes increased synthesis of yolk and albumen (Traore *et al.*, 2025). Conversely, high temperatures reduce food intake and limit the supply of calcium, protein, and energy necessary for egg formation, explaining the decrease in weight observed during hot seasons (Wang *et al.*, 2025).

Finally, seasonal variation in the shape index suggests that environmental conditions influence not only egg size and shape but also shell strength (Traore *et al*., 2025). The more elongated eggs observed during the cold dry season may reflect better physiological regulation of shell formation. In contrast, the most rounded eggs produced during the cold rainy season may indicate a slight change in the dynamics of calcification and shell membrane deposition. However, the observed values fall within the range generally reported for local hens and remain consistent with good incubation suitability (Tunsisa and Reda, 2022; Traore *et al*., 2025).

Age significantly influenced all sperm parameters in local roosters of the Konde ecotype, with generally optimal performance in breeding roosters aged 15 to less than 24 months. This age group exhibited the highest values for total motility, progressive motility, ejaculate volume, and sperm concentration. In contrast, roosters aged 24 to 36 months had the highest rates of dead sperm and morphological abnormalities. These results indicate a decline in several sperm characteristics among the oldest roosters, whereas the 15 to 24-month age groups generally exhibit the most favorable sperm characteristics. This trend suggests improved reproductive function during sexual maturation, followed by a gradual deterioration in sperm characteristics with advancing age. Our results are consistent with those of Juiputta *et al*. (2025), who reported that age significantly influenced semen volume, total motility, concentration, viability, and sperm abnormalities in local Thai roosters. These authors observed the best sperm characteristics in the youngest roosters and the lowest values in older breeding roosters, highlighting the importance of age in selecting breeding males. The decrease in motility and concentration observed in 24–36-month-old roosters, along with increased dead sperm and abnormalities, may reflect physiological changes associated with reproductive aging. According to Ghadimi *et al.* (2024), aging in roosters is accompanied by declining sperm quality and increased oxidative stress, whereas improving antioxidant status can partially restore sperm motility, viability, and concentration.

This interpretation is also supported by Shanmugam *et al.* (2014), who indicate that rooster sperm, rich in polyunsaturated fatty acids, are particularly vulnerable to reactive oxygen species. Increased oxidative stress with age could cause lipid peroxidation and impair sperm membranes, mitochondria, and motility, thereby promoting mortality and morphological abnormalities. However, the

severity of the age-related effect may vary depending on genotype and rearing conditions. Differences among poultry populations could be linked, in particular, to genetics, nutrition, management practices, and the environment. Thus, the performance observed in the Konde ecotype suggests that the period from 15 to less than 24 months may represent a favorable window for selecting and using breeding stock; however, studies incorporating fertility rates, hatch rates, hormonal profiles, and markers of oxidative stress should confirm this hypothesis.

This study also highlights a significant seasonal effect on bulk motility, progressive motility, the percentage of dead sperm, and sperm concentration in local roosters of the Konde ecotype. The best motility and concentration were observed during the cold dry season, while poor sperm quality was recorded during the hot dry season, suggesting that thermal conditions are an important factor in variation in reproductive function. This trend is consistent with Pimprasert *et al.* (2023), who observed in local Thai roosters that sperm concentration peaked in winter and sperm quality was lower during hot and rainy periods. The decrease in sperm concentration and motility during the hot dry season may reflect heat stress affecting overall poultry physiology, particularly spermatogenesis and sperm function. Elevated body temperature leads to the release of stress hormones, including adrenocorticotropic hormone (ACTH) (Shida *et al.*, 2020). This hormonal imbalance can disrupt testicular function, increase reactive oxygen species (ROS) production, and promote lipid peroxidation of sperm membranes. Avian sperm, which is particularly rich in polyunsaturated fatty acids, is thus highly susceptible to oxidative damage. El-Prollosy *et al.* (2024) demonstrated that chronic heat stress in roosters notably reduced sperm concentration and viability, whereas improving antioxidant status could mitigate these effects.

The increase in the proportion of dead sperm during hot dry and hot rainy seasons supports this hypothesis. This could reflect impaired sperm membrane integrity and functional capacity under the combined effects of temperature and humidity. In a study conducted on Spanish roosters raised under natural conditions, Santiago-Moreno *et al.* (2009) also reported seasonal variations in concentration, membrane integrity, and acrosome integrity, with a deterioration in sperm characteristics during periods of extreme temperatures. However, the absence of a significant seasonal effect on ejaculate volume and sperm abnormalities in our study contrasts with some previous observations. Santiago-Moreno *et al*. (2012), did not observe a significant seasonal effect on several parameters of fresh semen in different breeds of Spanish hens. These differences may be related to genotype, climatic adaptation, the age of the breeding birds, nutrition, and heat-stress intensity. Overall, the cold dry season appears to be more favorable for producing high-quality semen in the Konde ecotype. In contrast, hot periods appear to be more detrimental to sperm function.

The significant influence of season on reproductive function in the local Konde chicken is confirmed by the correlation between increases in the temperature-humidity index (THI) and declines in reproductive performance. Periods characterized by the lowest THI values, particularly November–February (68–74) and cooler periods, showed the best fertility, hatchability, and sperm quality. Conversely, the high THI values recorded in March–April (84–88) were associated with a marked decrease in fertility (44.33%) and hatchability (65.21%), as well as increased early (45.03%) and late (25.08%) embryonic mortality. This trend suggests that increased heat stress is a major factor limiting reproduction in the Konde ecotype. The THI appears to affect both male and female components of reproduction simultaneously. In roosters, more adverse thermal conditions were associated with decreased progressive motility (57.22%) and sperm concentration (1.61×10^9 sperm/mL), along with an increased proportion of dead sperm (23.88%). Heat stress can disrupt spermatogenesis, increase reactive oxygen species production, and promote lipid peroxidation of sperm membranes, which are particularly vulnerable in birds. Similar results have been reported in local Thai roosters, in which seasonal variations in the THI were associated with changes in sperm concentration and quality (Pimprasert *et al.,* 2023). obtained results are also consistent with those of Juiputta *et al*. (2025), who demonstrated in local Thai roosters that an increase in the temperature-humidity index was associated with reduced sperm production, with the most favorable values observed under more moderate thermal conditions.

In hens, an increase in the THI was also associated with a decrease in laying rate, egg weight, and fertility. In particular, heat stress reduces feed intake and can compromise the energy, protein, and mineral intakes necessary for egg formation. The combined effects on oocytes, sperm, and egg quality may thus explain the decreased hatchability and increased embryonic mortality observed during hot periods. Review studies on avian heat stress also report negative effects on egg production, egg weight, sperm quality, fertility, and hatchability (Kumar *et al.*, 2021). However, age may interact with THI. The 15–24-month age group, which exhibited the best sperm and reproductive characteristics, may have a greater physiological capacity to maintain reproductive homeostasis. Conversely, aging breeding birds may be more sensitive to environmental stresses. Recent studies on local roosters also show a significant relationship between age and sperm characteristics, with several parameters declining among older breeders (Juiputta *et al*., 2024). Thus, the results suggest a consistent biological relationship between high THI, impaired gamete quality, reduced egg-laying performance, and decreased embryonic viability. Overall, this study highlights that the optimal age of breeding hens (15–24 months), combined with cool climatic conditions, constitutes the most favorable combination for simultaneously maximizing egg production, fertility, hatchability, and egg quality in local hens of the Konde ecotype. These results provide original data on traditional poultry systems in West Africa and may help develop breeding management strategies adapted to tropical conditions.

CONCLUSION

This study highlights the combined importance of breeding-stock age and thermal conditions in determining the reproductive potential of the local Konde ecotype chicken in Burkina Faso. Breeding stock aged 15 to 24 months exhibited the most favorable performance, with high fertility and hatchability, low embryonic mortality, and superior sperm quality. Beyond 24 months, the decline in fertility and several sperm parameters, combined with an increase in late embryonic mortality, suggests a gradual decline in reproductive efficiency associated with aging. Analysis of thermal conditions also reveals a clear association between higher THI values and declining reproductive performance. Periods with moderate THI values (68–74) were associated with the best performance in egg production, fertility, hatchability, and sperm quality, whereas high values (84–88) corresponded to decreased fertility and hatchability and a significant increase in embryonic mortality. These observations indicate that heat stress is likely seasonal variability in the reproductive performance of the Konde chicken. From zootechnical perspective, these results suggest prioritizing breeding stock aged from 15 to 24 months and scheduling breeding and incubation operations during periods characterized by moderate THI. During hot periods, mitigation measures such as improved ventilation, constant access to cool water, reduced stocking densities, dietary adjustments, and limiting handling to the hottest hours of the day could help maintain reproductive performance. Further studies, however, will need to directly quantify the relationship between the THI and reproductive parameters using regression or mixed models, particularly considering age × THI interactions. Determining a THI threshold specific to the Konde chicken would be a significant step toward developing strategies to adapt to climate change and sustainably strengthen conservation and genetic improvement programs for this ecotype in Burkina Faso.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

Not applicable

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AI TOOL DECLARATION

The authors declare that no AI and related tools are used to write the scientific content of this manuscript.

DATA AVAILABILITY

Data will be available on request

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