International Journal of Environment, Agriculture and Biotechnology
Vol-8, Issue-6; Nov-Dec, 2023
Peer-Reviewed International Journal
Journal Home Page Available: https://ijeab.com/
Journal DOI: 10.22161/ijeab

Laying and growth performance of local chicken (*Gallus gallus domesticus*) ecotype Konde in Burkina Faso

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Received: 17 Oct 2023; Received in revised form: 25 Nov 2023; Accepted: 02 Dec 2023; Available online: 16 Dec 2023

Abstract— *Limited information exists regarding the zootechnical performance of the local chicken ecotype Konde. The objective of this study was to evaluate the laying and growth performance of local hens Gallus gallus domesticus ecotype Konde in a semi-intensive production system. A founder group of breeders (30 hens and 6 roosters) from the Boulgou Province (Garango, Zabré and Tenkodogo) was set up at a ratio of one (1) rooster for five (5) hens. Eggs were collected and identified daily. After five days of collection, eggs were naturally incubated under large brood hens (15 to 20 eggs) and then transferred to a compartmentalized and numbered hatcher. These incubations resulted in 306 identifiable one-day-old chicks (106 in the wet season, 103 in the cold dry season and 100 in the hot dry season). The individual weight (IW) of the chicks was recorded every week from hatching to three (3) months of age. Carcass characteristics were assessed on 10 birds per rearing period at 3 months of age. The laying rate was 33.60% during a 180-day laying period. Observed fertility and hatching rates were 60.33 and 80.31%, respectively. The average weight, length and large diameter of the eggs were 41.33 g, 48.75±2.07mm and 36.42±1.6mm, respectively. The results showed that chicks with an average hatching weight of around 28g reached, at three months of age, 926.64 ± 153 g, 884.06 ± 133 g, and 857.44 ± 105 g during the rainy, cold-dry, and hot-dry seasons, respectively. Carcass yield was 62.19, 66.46, and 65.91% in the rainy, hot, and dry seasons, respectively. A detailed economic evaluation showed a gross profit of 922 FCFA per bird at 3 months of age. Based on the growth performance, the local chicken ecotype Konde could be used for meat production. However, further improvement of performance and sustainability of the chicken's ecotype Konde through genetic selection and management tools is still needed.*

Keywords— ***local chicken ecotype Konde, laying, growth, carcass yield, Burkina Faso***

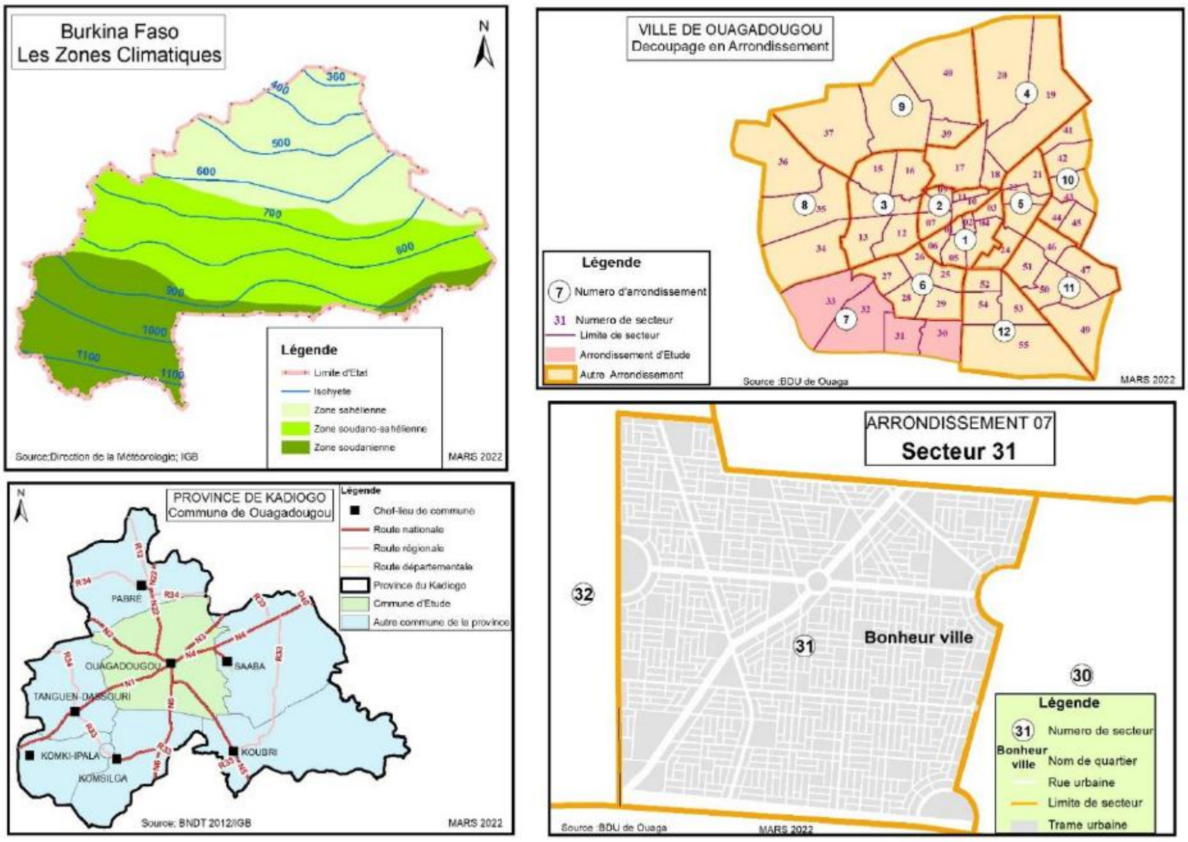
I. INTRODUCTION

Poultry farming is practiced in all countries of the world and conducted by all social strata of the population (Lara and Rostagno, 2013; FAO, 2019a; Ngongolo *et al.,* 2021). It is therefore an important lever for economic growth and a powerful tool to tackle poverty and food insecurity in several areas of the world including Burkina Faso (Ouattara *et al.*, 2014a; Ouedraogo *et al.*, 2015). In Burkina Faso, the poultry population is estimated at around 45 million birds and is composed of chickens (76.3%), guinea fowl (19.2%), pigeons (3.7%), ducks (0.7%), and turkeys (0.1%) (FAO, 2019b). The poultry sector plays a prominent role in the Burkinabe livestock sub-sector. It accounts for 6% of agricultural value added ($0.14 billion) and contributes more than 140,000 and 6,000 tons of meat and eggs per year, respectively (FAO, 2019b). The per capita consumption of poultry meat and eggs in Africa is estimated at 8kg and between 45 and 50 eggs (about 1kg) per person and year (FAO, 2019b). Local chicken and other local poultry products are better appreciated by the consumers compared to products of exotic breeds (Rajkumar et al., 2017) largely due to hardiness and organoleptic properties of the meat. Local poultry breeds accounts for over 98% of the national poultry population (FAO, 2019b). Despite its socio-economic impact and its important contribution to the population food security, the productivity of the local poultry population remains low compared to exotic breeds (FAO, 2019b). Thus, local poultry production is well below the needs of the population. The unbalance between the demand and the supply produced by local poultry breeds has forced Burkina Faso to turn to imports of exotic chickens to meet national consumption needs, estimated at about 37,000 tons of chicken meat annually (FAO, 2019b). The poor performance of traditional poultry farming is due to several factors; chief among them is the low genetic potential of the breeding stock and the artisanal husbandry system characterized by low scientific and economic investments (Ouattara *et al.*, 2014a; Ouedraogo *et al.*, 2015). However, the promotion of local poultry farming and the gradual improvement of farming technique are proving to be the determining factors for economic development (Yapi-Gnaore et al. 2011) and the safeguarding of genetic resources and biodiversity (Yapi-Gnaore *et al*., 2011; Tadano *et al.*, 2013) . Several studies (Akouango et al., 2010; Yapi-Gnaore *et al.*, 2011; Rajkumar *et al.*, 2017) have been carried out to investigate the laying and growth potentials of local chicken. However, information about the zootechnical performance of the ecotype Konde is scant at best. In spite of the good potential of the ecotype Konde to be used as a broiler breed (Zare et al., 2021), there is a persistent danger for its disappearance (Ouandaogo, 1975; Zare et al., 2021). The general aim of the present study is to dissect the performance of the local hen (*Gallus gallus domesticus*), particularly that of the ecotype Konde in improved breeding systems with the specific objective of evaluating the laying and growth performance of the local chicken ecotype Konde in a semi-intensive rearing system.

II. MATERIAL AND METHODS

2.1. Presentation of the study area

The present study was carried out at a poultry farm belonging to the station of the Institut de l'Environnement et de Recherches Agricoles (INERA) in Ouagadougou, Burkina Faso. This poultry farm is located in the peri-urban area of the town of Ouagadougou in sector 31 of the seventh district, capital of the province of Kadiogo and it is located in the center of Burkina Faso (Map 1).



Map 1: Map location of the study area in the commune of Ouagadougou (IGB, 2014).

2.2 Materials

2.2.1. Biological material

In concordance with the sample size requirements per breed or population for the study of domestic animal biodiversity, the FAO guidelines recommend at least 25 individuals per breed/population (FAO, 1998). The current study involved 36 ecotype Konde chicken birds aged between 5 and 6 months. Hens (n=30) and roosters (n=6) of the breeding nucleus came from different villages in the Boulgou province. These chickens were selected based on their morpho-biometric characteristics, notably plumage, crest, height on legs, and leg color as suggested by Zare *et al.*(2021). They were randomly distributed into 6 pens according to their area of origin. Several incubations were carried out and resulted in 306 identifiable day-old chicks distributed across three time periods: 106 birds in the rainy season, 103 birds in the cold dry season, and 100 birds in the hot dry season.

2.2.2. Rearing building

The trial building was subdivided into eleven pens (3 m high, 2.25 m long and 1.15 m wide). Each pen housed one rooster and 5 hens. The building model used was an open structure where the environmental conditions were not controlled. A hygrometer was used to measure relative humidity and temperature. Wood shavings were used as bedding for the welfare of the chickens.

2.3 Method

2.3.1. Monitoring of laying and incubation

Eggs were removed as soon as they were laid and coded based on the pen location "C", the hen's y-number "P" and the egg's rank n (CxPyn). Each egg was recorded according to the breeding cock and the hen on individual identification cards. Eggs that could not be properly identified were coded as non-identifiable (NI). Properly identified eggs were placed in natural brooding on the basis of 15 to 20 eggs per broody hen. Two candling sessions were carried out at day 7 and 18 respectively. Immediately after the second candling, the eggs in the beginning of hatching were taken from under the broody hens and put in an electronic incubator transformed into a hatcher containing a labeled (1 to 35) box. Replication (R) involved the egg-laying cycle (duration of egg-laying until brooding instinct or pause period) of the parents and the first generation. The egg collection was extended over a period of 6 months in order to generate five replicates.

The collected data was used to evaluate the following zootechnical parameters: General laying rate (GLR) and individual laying rate (ILR);

$$GLR = \frac{number\ of\ eggs\ laid}{laying\ duration * hens} X100$$

$$ILR = \frac{number\ of\ eggs\ laid\ by\ a\ hen}{laying\ duration} X100$$

The actual fertility (FR) and hatching (HR) rates were calculated according to the formulas of Sauveur (1988):

$$FR = \frac{number\ of\ fertile\ eggs}{number\ of\ eggs\ laid} X100$$

$$HR = \frac{number\ of\ tached\ eggs}{number\ of\ fertile\ eggs} X100$$

Embryonic mortality rates were calculated using the following formulas: early embryonic mortality rate (EEMR), late embryonic mortality rate (LEMR) and chick mortality rate (CMR),

$$EEMR = \frac{number\ of\ eggs\ with\ dead\ embryo\ at\ day\ 15}{number\ of\ fertile\ eggs} X100$$

$$LEMR = \frac{number\ of\ eggs\ with\ dead\ embryo\ at\ day\ 24}{number\ of\ fertile\ eggs} X100$$

$$CMR = \frac{number\ of\ deaths\ in\ a\ period}{number\ of\ birds\ during\ the\ same\ period} X100$$

The average egg Shape index (ESI) used to measure the mechanical strength of the shell was calculated according to the formulas presented by Sanfo *et al.*, (2012)

$$ESI = \frac{length}{width}$$

Egg characteristics were calculated using the following formulas: clear egg rate (CER), average egg weight (AEW) and average number of eggs per hen and per year (ANEHY).

$$CER = \frac{number\ of\ clear\ eggs}{number\ of\ incubated\ eggs} X100$$

$$AEW = \frac{nsum\ of\ egg\ weights}{number\ of eggs}$$

$$ANEHY = \frac{sum\ of\ eggs\ laid\ by\ all\ hens\ per\ year}{number\ of\ hens}$$

2.3.2. Production and rearing of chicks

Eggs were collected and identified daily and kept in incubators then put in natural incubation from the 5th and 7th day of collection in the dry and rainy seasons, respectively. The chicks were weighed and identified as soon as they hatched. They were reared in the brooder from the first week to the third week at a density of 25 chicks/m2 and then from the fourth week at a density of 10 chicks/m2 in screened pens (4.5m x 1.15m). Each chick was identified with a numbered plastic ring placed on its leg. These bands were replaced at five (5) weeks of age with numbered metal bands attached to the right-wing membrane.

2.3.3. Feeding of hens and chicks

Each laying hen received 80 g of feed per day. A summary of the feed characteristics is presented in Table 1. The chicks received the same ration consisting of the starter feed (galdus) up to 2 weeks of age followed by the feed presented in Table 1. The chicks received 7 g of galdus feed per day for 3 days and 10 g of galdus feed per day for 4 days for the first week of age (galdus is a high nutritional value starter feed). Starting at day 14, they received the growth feed. Birds were weighed weekly at which time the ration was increased by 5 g for each bird during the three months of the study. The feed was distributed in the mornings. Water was provided ad libitum using the national water distribution network. The individual weights (IW) of chicks were recorded weekly from hatching to three (3) months of age. Weighs were collected before feed distribution. After hatching, the chicks were placed in a brooder equipped with a heating bulb (60 W) for one month.

The following intake related parameters were calculated: feed intake index (FII) and average consumption per bird (ACB).

$$FII = \frac{feed\ consumption\ during\ a\ period\ (g)}{Egg\ mass\ during\ the\ period\ (g)}$$

$$ACB = \frac{amount\ of\ feed\ served - refusals}{number\ of\ birds}$$

Table 1. Bromatological composition of feed rations

Ingredients (%)	Starter feed (galdus)	Growth feed	Laying feed
	1 to 14 days	**15 to 84 days**	≥85 days
Corn (Maize)	-	60	66.5
Wheat bran	-	0	9.35
Soybean	-	10.85	0
Soybean meal	-	14	9
Cottonseed cake	-	3	2
Fish meal	-	6	5.3
Oyster shells	-	2	4.5
Salt	-	0.15	0.15
Broiler premix	-	2.5	2.5
Methionine	-	0.1	0.25
Lysine	-	0.3	0.21
Iron Sulfate	-	0.1	0.14
Bicalcium phosphate	-	1	0.1
Total	-	**100**	100
	Nutritional composition		
Metabolizableenergy (kcal/kg)	**3150**	**3016.24**	**2855.8**
Fat (%)	**-**	**5.15**	**3.59**
Crude protein (%)	**22**	**21.19**	**16**
Crude fiber (%)	**-**	**3.15**	**3.16**
Lysine (%)	**1.3**	**0.48**	**0.92**
Methionine (%)	**0.6**	**0.82**	**0.56**
Methionine + Cys (%)	**0.95**	**1.38**	**0.82**
Calcium (%)	**0.95**	**0.46**	**2.05**
Phosphorus (%)	**0.60**	**0.13**	**0.28**
Sodium (%)	**-**	**0.25**	**0.13**
Chloride (%)			**0.23**

2.3.4. Growth rate and carcass characteristics

Carcass characteristics were assessed by sacrificing ten (10) animals at the age of twelve (12) weeks per rearing period. Birds were slaughtered in the morning on an empty stomach. The birds were first weighed to determine their live weight. After bleeding, they were plucked to determine the weight of feathers, carcass, liver, gizzard, intestines, legs, and head. The data collected allowed us to calculate the following zootechnical parameters: average daily gain (ADG), feed conversion (FC) and carcass yield (CY).

$$ADG = \frac{weight\ gain\ during\ a\ week}{7}$$

$$FC = \frac{feed\ consumed\ during\ a\ period}{weight\ gain\ during\ the\ same\ period}$$

$$CY = \frac{carcass\ weight}{live\ weight\ at\ slaughter} X100$$

2.3.5. Economic studies

In order to evaluate the economic performance, a financial analysis in the form of a profit and loss account was carried out during all the breeding seasons. The results obtained were divided into variable expenses, fixed expenses, and products.

To assess the economic profitability, the following formulas were used:

Feed cost/phase =FC* price per kg of feed (FCFA)

where FC is the total feed consumed (in kg) per phase (Start-up and growth)

Feed cost = ∑ Feed cost/phase (FCFA)

Sale of chickens = Number of chickens * sale price of a chicken (FCFA)

Cost of production = ∑ expenses (FCFA)

Profit = Income - expenses (FCFA)

2.3.6. Sanitary protocol

Basic hygiene measures were applied at the level of the rearing equipment by regular washing and disinfection and sometimes the application of sanitary voids in the pens. In general, the animals were maintained in accordance with the vaccination schedule for local chickens. As biosecurity measure, a foot bath was installed. The health monitoring adopted in the trial was that established by the Centre de Promotion de l'Aviculture Villageoise (CPAVI).

2.3.7. Statistical analyses

The collected data was stored as an Excel spreadsheet (Microsoft Excel 2016). Data processing and analysis were implemented using "R" software (version 4.1.1). Charts and tables were produced using Microsoft Excel 2016 software. Analysis of variance using Turkey's test for mean separation was performed on the parametric quantitative data. Nonparametric analyses were performed by the Kruskal Wallys test using the Pairwise Test for median separation.

III. RESULTS

3.1. Laying performance

The laying rate average was 33.60% and ranged between 26.20 and 44.94%. This translates to an average of around 61 ± 3 eggs per hen during a six-month period (Table 2). In average, hens start laying at about 20 weeks of age. However, there is substantial variation as some hens start laying at 2 years of age. Fertility rate ranged between 54 and 68.26% with an average of 60.33%. The early and late embryonic mortality rates were 7.80% and 18.44%, respectively. The average hatching rate was around 82% with a maximum and minimum of 84.60% and 74.82%, respectively.

Table 2. Production and reproductive performance of Konde ecotype hens during a 24-week period.

	Production performance				
	AL (Weeks)	ANE/ Laying Cycle	ALI/ Cycle	AEH / P	ALR (%)
Mean	20 ± 1.16	11 ± 3	16 ± 2	61 ± 3	33.60
Maximum	24	17	18	81	44.94
Minimum	20	10	11	48	26.20
	Reproduction performance				
	FR (%)	CER (%)	EEMR (%)	LEMR (%)	HR (%)
Mean	60.33	39.67	7.80	18.44	81.56
Maximum	68.26	45.85	10.17	25.18	84.60
Minimum	54.15	31.74	6.19	15.40	74.82

AL: Age at laying; ANE: Average number of eggs; ALI: Average laying interval; ALR: Average laying rate; AEH/P: Average eggs per hen; EEMR: Early embryonic mortality rate; LEMR: Late embryonic mortality rate; HR: Hatching rate; FR: Fertility rate; CER: Clear egg rate

3.2. External egg quality characteristics of local ecotype Konde

The average egg weight (AEW) was 41.33 g and varied between 38.37 (first month of laying) and 42.54 g (six month of laying) as indicated in Table 2. The AEW increased, as expected, with the age of the hen. The average egg length (EL) and large diameter of the eggs (LD) were 48.75±2.07mm and 36.42±1.6mm, respectively (Table 3). Mean egg shape index (ESI) ranged between 0.74±1.31 to 0.75±1.58 with a mean of 0.75±0.01. Out of a total of 1815 eggs collected, hens laid more eggs with white shells (79.12%) than with dirty white shells (20.88%) (Table 3). All eggs were oval in shape (100%).

Table 3. Local chicken ecotype Konde egg characteristics

Quantitative external egg characteristics							
	M1	**M2**	**M3**	**M4**	**M5**	**M6**	**Mean**
AEW (g)	38.37±3.06	39.72±3.10	41.6±3.37	42.52±4.15	44.44±7.11	42.54±3.84	41.33±2.37
EL (mm)	46.27±1.45	47.14±1.50	47.85±1.93	48.89±1.79	51.23±3.60	51.12±1.38	48.75±2.07
LD (mm)	34.56±1.25	34.93±1.12	35.67±1.24	36.94±1.17	38.06±2.03	38.33±0.95	36.42±1.6
ESI	0.75±1.35	0.74±1.31	0.75±1.58	0.76±1.48	0.74±2.81	0.75±1.16	0.75±0.01

External egg qualitative characteristics			
Egg characteristics		**N**	**%**
Color	white shells	1436	79.12
	dirty white shells	379	20.88
Total		1815	100
Egg shape	**Round**	0	0
	Oval	1815	100
Total		1815	100

M_i: Month i (i=1, 2…,6); N: number of eggs; %: total percentage

3.3. Quantity of feed served and consumed

Feed intake index for egg production (FIIE) ranged from 6.23 to 7.33 with an average of 6.62±0.5 (Table 4). The average daily feed consumption per hen (ADFCB)was 53.91±4.10 g and ranged between 49.72 and 59.38 g (Table 4).

Table 4. Feed consumption parameters of local Konde ecotype chickens

	N	AFSB(g)	RB	ADFCB	FIIE
Mean	30	80	26.09±4,10	53.91±4,10	6.62±0.5
Maximum		80	30.28	59.38	7.33
Minimum		80	20.62	49.72	6.23

N: Number of birds; AFSB B: amount of feed served per bird; RB: Refusals per bird ; ACB: Average daily feed consumption per bird; FII / B: Feed intake Index per bird for eggs production.

3.4. Average daily gain, feed intake, and mortality rate at 12 weeks of age

The average daily gain (ADG) varied with the age of the chicks (Table 5). The mean ADG was 10.69, 10.17, and 9.88 g in the wet, cold dry, and hot dry seasons, respectively. Across all rearing seasons, the ADG was 10.25 g. There was no significant difference in ADG between seasons. The feed intake index per bird for meat production (FIIM) showed significant changes across the different rearing seasons (Table 5). The farm recorded cumulative FIIM was 3.41, 3.58 and 3.55 for the rainy, cold dry and hot dry seasons respectively. The highest FIIM was 4.48 and was observed in the seventh week during the hot dry season and the lowest (1.88) was recorded during the second week of the rainy season. The overall FIIM was 3.51 over the entire rearing period. However, there was no significant difference between the overall FIIM across seasons, although there were significant differences across some weeks.

Twenty-one birds died resulting in a general mortality rate of 6.80% (Table 5). The highest mortality rate (9.43%) was observed during the rainy season (10 birds died), followed by the warm season with a total of seven deaths (mortality rate of 6.80%). The lowest mortality rate (4%)

was observed during the cold dry season with only four deaths. For the rainy season, the highest mortality rate was observed during the 4th week with four (4) losses or 3.81%. During the cold dry season, the highest mortality rate was observed during the 6th week with two (2) deaths or 2.02%. For the hot dry season, the highest mortality rate was observed during the 2nd week with two (2) deaths or 1.98%.

Table 5. Evolution of average daily gain (ADG), feed intake index for muscle (FIIM), and mortality rate during 3 seasons for Konde ecotype hens

	ADG RS (g)	FIIM RS	Mortality RS	ADG CDS (g)	FIIM CDS	Mortality CDS	ADG HDS (g)	FIIM HDS	Mortality HDS
S1	4.23[a]	1.89[a]	0.94	2.20[b]	3.80[b]	0	2.01[b]	4.08[b]	1.94
S2	7.15[a]	1.88[a]	0	3.71[b]	3.85[b]	0	4.89[c]	2.87[a]	1.98
S3	6.50[a]	2.67[a]	0	5.83[b]	3.35[b]	0	6.50[a]	2.11[a]	0
S4	6.39[a]	3.53[a]	3.81	7.99[b]	2.95[b]	0	7.00[a]	3.19[ab]	0
S5	8.45[a]	3.21[a]	1.98	7.59[a]	3.73[a]	1	8.38[a]	3.09[a]	0
S6	10.13[a]	3.42[a]	0	9.27[a]	3.62[a]	2.02	9.01[a]	3.45[a]	0
S7	13.20[a]	3.03[a]	2.02	9.81[b]	3.99[b]	0	8.58[b]	4.48[b]	1.01
S8	12.70[a]	3.54[a]	1.03	13.20[a]	3.36[a]	0	10.19[b]	4.02[a]	0
S9	14.47[a]	3.43[a]	0	13.67[a]	3.64[a]	0	12.65[a]	3.92[a]	1.02
S10	15.24[a]	3.61[a]	0	14.80[a]	3.72[a]	1.03	16.55[a]	3.29[a]	0
S11	15.35[a]	3.90[a]	0	16.56[b]	3.62[a]	0	14.81[a]	3.93[a]	1.03
S12	14.44[a]	4.49[a]	0	17.45[b]	3.71[b]	0	18.05[b]	3.56[b]	0
Mean	10.69[a]	**3.41[a]**	9.43	10.17[a]	**3.58[a]**	4	9.88[a]	**3.55[a]**	6.8

Means marked with the same letter in the same row are not significantly different (p>0.05) at the Kruskal Wallis pairwise test; RS: Rainy Season; CDS: Cold Dry Season; HDS: Hot Dry Season; S: week; each number indicates week number or age of birds;

3.5. Growth curve of chicks

The average hatch weight was 29.61 (± 3.16), 28.85 (± 3.32, and 27.19 g (± 3.10 g) during the cold dry (CDS), the rainy (RS), the hot dry (HDS) seasons, respectively. The average hatch weight for all rearing seasons was 28.55 g (Fig 1). Difference in hatch weight was not significant between RS and CDS. However, hatching weights were significantly different between the latter seasons and HDS. The mean body weight (BW) of chickens at twelve (12) weeks of age was 926.64 g ± 153.18 g (877.27 g ± 120.06 g and 976 g ± 167.43 g for females and males, respectively) during RS, 884.06 g ± 132.92 g (839, 69 g ± 101.85 g and 923.22 g ± 145.85 g for females and males, respectively) during SSF, and 857.44 g ± 105.43g (837g ± 96.68 g and 884.85 g ± 111.51 g for females and males, respectively) during HDS as presented in Fig 1. The highest (1,400g ± 132.92g) and lowest (644g ± 132.92g) live weights at twelve (12) weeks of age were observed in CDS.

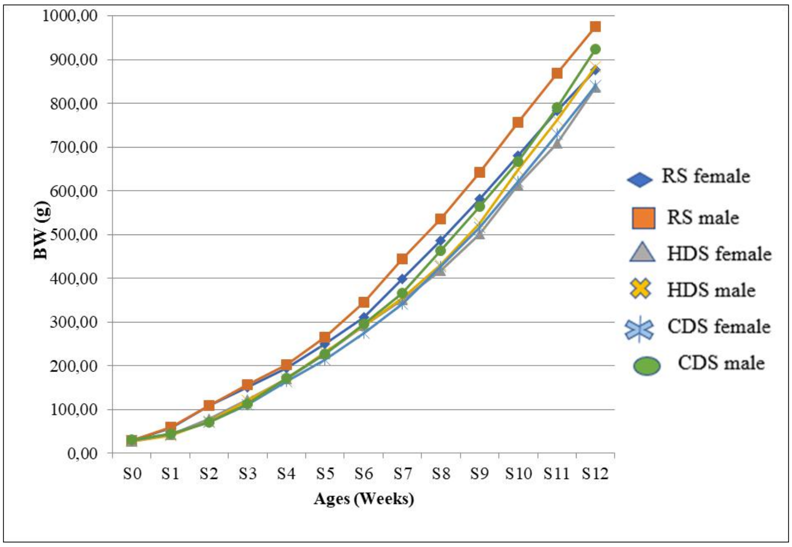


Fig 1. Evolution of body weight of local chicken ecotype Konde during the Rainy (RS), Cold and Dry (CDS), and Hot and Dry (HDS) seasons

3.6. Carcass yield

The carcass characteristics at 12 weeks of age are presented in Table 6. Across all rearing seasons, the average body weight of birds used for carcass characteristics was 998.73 g. The Average carcass weight was 648.50 g and the overall carcass yield was 64.93% (Table 6). The highest carcass yield (65.91%) was observed during the HDS season followed by the cold dry season with a carcass yield of 65.37%. The rainy season had the lowest carcass yield (62.19%). Carcass yield was significantly difference between the RS and both CDS and HDS. A significant difference in carcass yield was observed between males and females (males had higher carcass yield).

Table 6. Organ weights and carcass yield at 12 weeks of age

Season	Sex	Body Weight(g)	Carcass Weight (g)	Feathers (g)	Head+ tarsus (g)	Intestines (g)	Liver (g)	Gizzard (g)	carcass yield (%)
RS	F(n=5)	862.40	516.60	44.80	79.40	74.20	20.40	27.60	59.90^{a}
	M(n=5)	1033.40	662.40	44.20	136.80	77.60	26.80	34.20	64.10^{b}
	Total (n=10)	**947.90**	**589.50**	**44.50**	**108.10**	**75.90**	**23.60**	**30.90**	**62.19^{a}**
CDS	F(n=6)	1059	688.00	46.67	81.00	43.00	25.00	25.33	64.96^{b}
	M(n=5)	1131.00	744.00	85.00	90.14	79.43	27.00	42.00	65.78^{c}
	Total (n=11)	**1094.20**	**727.20**	**73.50**	**87.40**	**68.50**	**26.40**	**37.00**	**65.37^{b}**
HDS	F(n=5)	826.50	532.50	45.00	78.00	35.50	22.50	29.00	64.43^{b}
	M(n=5)	986.00	652.88	74.75	84.13	59.88	21.63	35.00	66.21^{c}
	Total (n=10)	**954.10**	**628.80**	**68.80**	**82.90**	**55.00**	**21.80**	**33.80**	**65.91^{b}**
Mean	**Total (n= 31)**	**998.73**	**648.50**	**62.27**	**92.80**	**66.47**	**23.93**	**33.90**	**64.93**

Values with the same letter in the same column are not significantly different (p-value >0.05). RS: Rainy Season; CDS: Cold Dry Season; HDS: Hot Dry Season

3.7. Economic results

The price of a local one-day old chick was set at 650 F CFA to reflect current local chick market prices (Table 7). The price of galdus starter feed was set at 1000 F CFA per kilogram and grower feed at 300 F CFA per kilogram. The market price of local chickens was estimated at 3,000 F CFA. At the end of the rearing cycle, the gross margin (GM) was estimated at 265,542 F CFA (gross margin of 922 F CFA per bird).

Table 7. Evaluation of the economic profitability of Konde chickens at 12 weeks of age

Variables	Quantity	Unit price (FCFA)	Price (FCFA)
Chicks	309	650	200.850
Starter feed	44.57	1.000	44.571
Growth feed	828.46	300	248.537
Electricity et water bill	1	4.500	4.500
Litter	10	500	5.000
Veterinary products	1	25.000	25.000
Transportation	1	3.000	3.000
Labor	3	25.000	75.000
Depreciation		PM	
Total expenses		606.458	
Sale of chicken	288	3.000	864.000
Sale of manure	8	1.000	8.000
Total sales		872.000	
Gross margin			265.542
Gross margin/chicken			922

IV. DISCUSSION

4.1. Breeding and production performance of the local hen ecotype Konde

Hens start laying at around 20 weeks (5 months) of age. This result is similar to that observed by Ouattara *et al.* (2014a) in Burkina Faso. Older ages of 6 and 7 months at start of laying were reported by Moula *et al.* (2012a) in Algeria, Fosta *et al.* (2007) in Cameroon, *Akouango et al.*(2010) and Moula *et al.*(2012b) in Congo, Hailu et al, (2019) in Ethiopia, Moula *et al.* (2009) in Belgium, and Dalal et al. (2019) in northern India. The difference in age at the start of laying is due to genetic factors and rearing and feeding conditions. In the present study, the fertility rate observed in hens was 60.33%. It is lower than the 64.73 and 73.40% found in Burkina Faso by Ouattara *et al.*(2014b) using experimental and control diets, respectively. It also was lower than the 78.96% reported in Congo by Akouango *et al.* (2010). Several reasons including genetics potential, management, and feeding factors could explain these differences.

The average laying rate was 33.60% corresponding to a production of 61 ± 3 eggs during a 6-month laying period (around 120 eggs per year). This is higher than the 30.52% found by Ouattara *et al.* (2014b) in Burkina Faso using an experimental diet and 29.67% for a control diet. However, it was lower to the 44.6% found in Algeria for local Kabilye hens reported by Moula *et al.* (2012a). The average hatching rate (81.56%) was higher than the 53.81 and 58.79% reported by Ouattara *et al.* (2014b) using two different diets, 62.06% reported by Akouango *et al.* (2010) in Congo and 76.1% presented by Hailu *et al.* (2019) in Ethiopia. However, it was similar to hatching rate reported by Fotsa *et al.*(2010) in central and southern Cameroon (79.7 and 83.3%). This variation in hatching rate across studies is likely to be due to differences in genetic background, nutrition, age, rearing and incubation management, and breeder quality (Rajkumar *et al*., 2017).

4.2. External egg qualities

The average egg weight at the start of laying was 38.37 g. Weight variation at that stage was largely due to genetic factors (Egahi *et al.*, 2013). Age has an effect on the variation of egg weight where small eggs are produced at the beginning of laying and they increased in size with the hen's age (Ouattara *et al.*, 2014a). The Average egg weight (41.33±2.37g) of local Konde hens was similar to those obtained by Ouattara *et al.* (2014b) in Burkina Faso

(41.07±1.37g) using experimental diet, and by Akouango *et al*. (2010) in Congo (41.91±0.5g). The average egg length (48.75 mm), and egg large diameter (36.42 mm) for the ecotype Konde were similar to those reported by Samandoulougou *et al.*(2016) for local hens in Burkina Faso. However, the average length and larger diameter found in this study were greater than those reported by Fayeye *et al.* (2005). The average shape index (0.75) was slightly higher than the 0.74 reported by Samandoulougou *et al.* (2016). The egg color (71.25% white and 28.75% dirty white) and egg shape (100% oval) distributions were different from the results reported by Samandoulougou *et al.*, (2016) who found that only 65% of the eggs were white and the remaining 35% were dirty white. Additionally, their results showed that 83% of the eggs were oval, 15% fusiform, and 2% round.

4.3. Feeding

Over the duration of the trial (24 weeks), the average feed conversion ratio, a measure of feed efficiency, was 6.62. The average daily feed consumption per hen was 53.91g. These results could be explained by climatic conditions, age, and the type of feed provided. Ouattara *et al.* (2014b) reported feed conversion ratios at 24 weeks of age of 8.52 and 8.37 using a control and an experiment diet, respectively.

4.4. Hatching weight

The average weight of chicks at hatching did not differ between rearing seasons. The average weight found in this study (28.55 g) across all rearing seasons was similar to that reported by Akouango *et al.* (2010) in Congo (28.38 g), Fosta *et al.*, (2007) in eastern Cameroon (28 g), and Yapi-Gnaoré *et al.* (2011) in Côte d'Ivoire (28.1 g). However, it was heavier than the 24 to 26.2 g for local hens in Cameroon, the 25.5 to 26.9 g for local breeds in Senegal and Côte d'Ivoire) (Nahimana et *al.*, 2017; Yapi-Gnaore et *al.*, 2011). On the other hand, it was lower than the 30.49 to 37 g obtained by Moula et al. (2009) for local breeds in Belgium. The discrepancies in weight with other studies could be explained by genetic differences between breeds as well as environmental and rearing conditions.

4.5. Mortality rate

The overall chick mortality rate of 6.80% observed in this study was similar to the 6.67% reported by Ouattara et al. (2014a) using local breeds of chickens reared in semi-intensive stations. Lower mortality rates ranging between 3.49 and 5.24% were reported by Akouango *et al.* (2010), and Moula *et al.* (2009). Other studies reported higher mortality rates ranging between 8.02% and 9.8% (Ouedraogo *et al.*, 2015). The low mortality rate could be explained, in part, by the relatively more rigorous health monitoring system. The highest mortality rate of 9.43% was observed during the rainy season due to the high temperatures and humidity favorable for the proliferation of several pathogens.

4.6. Growth rate

The mean ADG (10.25 g) for the entire rearing period (84 days) was quite low but within the range of reported values for local chicken breeds. This result is almost identical to that reported by Ouattara *et al.* (2014a) for local chickens in Burkina Faso. The ADG found in this study was higher than the 5.80 to 7.85 g reported by Msoffe *et al.* (2004), and Halima *et al.* (2007). The ADG was less than that of 12.04 g obtained in Belgium using the local Ardennaise breed bred during the same duration as the present study (Moula *et al.*, 2009). These differences can be explained by rearing conditions, environmental conditions, age and genetic potential.

The average chick weight at twelve weeks of age ranged between 857.44 g and 926.64 g. It was higher than the 355.7 to 544.5 g, 664 to 778 g, 563.98 to 770.51 g, and 511.4 to 622 g of the local breeds reported by Nahimana *et al.* (2017) in Senegal, Ouattara *et al.* (2014a) in Burkina Faso, Akouango *et al*. (2010) in Congo, Fosta *et al.* (2007) in Cameroon, respectively. The growth performance of the Kondé ecotype birds are similar to those reported by Yapi-Gnaoré *et al*. (2011) for local breeds in Côte d'Ivoire (855.4 to 891.5 g). However, they are lower than the 1042 g of the local breed Ardennaise presented by Moula *et al.* (2009) in Belgium and also lower than the 1100 g and 1304 g obtained from mixed breed chickens by Ouédraogo *et al.* (2015) in Sourou province, Burkina Faso. The differences between our results and those reported for other local chickens in Burkina Faso, Africa, and Europe can be attributed on top of the genetic potential of the chickens, feed, and rearing conditions to the marked heterogeneity in environmental factors. Birds in the hot and dry season have the lowest live weight at 12 weeks of age compared to the rainy and cold and dry seasons. This decline in growth rate is likely to be due to heat stress. In fact, several studies (Ahmad et al., 2022; Lara & Rostagno, 2013) have shown a decrease in feed intake and growth in chickens in the presence of heat stress.

4.7 Feed efficiency

The feed conversion ratio did not differ significantly between the rearing seasons. The average feed conversion ratio of 3.51 was similar to that found by Fosta (2008) in Cameroon (3.16-4.19). On the other hand, this feed conversion ratio was substantially lower compared to those of traditional chickens in Africa (Ayssiwede *et al.*, 2013). Additionally, it was lower than the values reported by Moula *et al.* (2009) in Belgium (7.2 to 8.1), Ouattara *et al.* (2014a) in Burkina Faso (4.4 to 4.9), and Ouattara *et al.*

(2014b) in Burkina Faso (4.5 to 5.5), respectively. Multiple factors including breed, rearing and management conditions, and environmental parameters could explain the differences in feed conversion rate across studies. However, it should be noted that local breeds of chicken across countries and regions have poor feed conversion ratios compared to so-called exotic or improved chicken breed (Ayssiwede *et al*., 2013).

4.8. Carcass Yield

The overall carcass yield (64.93%) found in the present study is similar to the results (61 to 79%) reported by Pousga *et al.*, (2019). However, the carcass yield in cockerels (65.53%) and in pullets (63.54%) was lower than the 78.43 and 71.49% reported by Akouango *et al.* (2010) for cockerels and pullets, respectively. Additionally, the estimates of carcass yield in this study were higher than those reported by Ouattara *et al*. (2014a) after 138 days of feeding (60.3 to 62.7). Carcass weight and yield in cockerels were significantly higher than in pullets. The lower weigh of female birds could be due to the higher deposition of abdominal fat in pullets (Ayssiwede *et al.*, 2013).

Organ measurements showed high weights for the head and legs (92.80 g). This is likely due to the fact that the ecotype Konde hens have larger tarsi than other local birds in Burkina Faso. A strong positive correlation was observed between live and carcass weights. Therefore, live weight could be a good predictor of both carcass weight and carcass yield. The weak correlation between hatching weight and live weight at 12 weeks means that the weight of the chicks at 12 weeks is weakly related to the weight of the chicks at hatching. Thus, hatching weight will have no power to predict bird weight and 12 weeks of age. Similar results were reported by other authors (Akouango *et al.*, 2010).

4.9. Economic Results

The gross margin per bird (922 F CFA) found in this study was lower than the estimates (1448 to 1639 F CFA) reported by *Ouattara et al.* (2014b). This large variation in gross margin is primarily the result of the variation in feed prices. As with exotic breeds, feed is the major production cost (>70%)

Conclusions

This study quantified the growth performance of local ecotype Konde hens in Burkina Faso. Under semi-intensive conditions, Konde hens could be raised for meat and egg production. Although the growth parameters are more satisfactory than the laying performance. In order to reach a weight of two kilos at 12 weeks of age, major improvements in management and genetic selection are needed. For the future sustainability of the Konde ecotype in Burkina Faso, a serious conservation and selection program needs to be implemented.

FUNDING

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

ACKNOWLEDGMENTS

The authors would like to thank the technical staff MAIGA Sayouba and NANA Abdoul Salam for their efforts during the conduct of this experiment.

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