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Effects of Sex and Rearing Season on Body Weight Gain and Growth Curve Parameters of Local Chickens in Niger

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ABSTRACT

Local chicken breeding is widespread in Niger, a country with harsh environmental conditions. This study aimed to investigate the effects of sex, temperature, and hygrometry variations on the body weight gain and growth curve of local Nigerien chickens. Two groups of local chickens were followed from hatching to 20 weeks of age. The first and second groups consisted of 96 and 124 chickens, respectively. Three seasons were identified based on continuously recording ambient temperature and humidity over a year. The dry and warm seasons (February, March, April, and May), the wet and warm seasons (June, July, August, and September), and the dry and cold seasons (October, November, December, and January). The average hatch weight was about 24 g, and monthly body weight gains ranged from 100 to 360 g. Asymptotic weights were 2214.02 ± 69.94 g and 1776.93 ± 63.57 g for roosters and 1380.25 ± 25.96 g and 1433.08 ± 71.24 g for hens. The sexual maturity rates indicate that hens are more precocious than roosters. Sex and season had significant impacts on the growth performance of the chickens. In conclusion, the results of the present study indicated that the optimal time to raise local chickens in rural Niger is from June to January, and males are better candidates for meat production.

Keywords: Growth curve, Hygrometry, Local chicken, Temperature, Weight gain

INTRODUCTION

Local chicken represents 55% of the Nigerien poultry population (RGAC, 2007). The production of local chickens contributes greatly to food and nutritional security, especially in rural areas (Ousseini et al., 2018). In addition, Niger is one of the countries in sub-Saharan Africa with the harshest agroecological conditions, mainly located halfway between the Sahara and the Sahel. This location results in a very marked seasonality of the climate, characterized by significant temperature and hygrometry differences between the seasons (CNEDD, 2000).

Traditional chickens seem to be acclimatized to all of Niger's agroecological zones because *gallinacea* is present throughout the country (FAO, 2009). However, due to their physiology, chickens are generally sensitive to significant variations in environmental conditions, such as humidity and temperature. Chickens are homeotherms but cannot eliminate heat sweating due to the presence of feathers (Geraert, 1991). In addition, the energy required to activate the physiological mechanisms of adaptation to high temperatures is important. It comes essentially from the diet or, in case of failure, from body reserves in the form of fatty tissue. This dietary energy is preferentially used to satisfy homeostatic needs rather than production needs (Tattersall et al., 2016). Therefore, in hot weather, food consumption increases without a parallel increase in production. This corresponds to poor feed efficiency, and thus, to an increase in production costs. (Geraert, 1991).

The study of local chickens in Niger is relatively new. A few studies have been conducted to characterize their production systems and their morphometry in rural

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areas (NECSD, 2000). In an experimental setting, the aim was to assess their growth performance (Hamani et al., 2022a) and their butchery ability (Hamani et al., 2022b) through the use of non-conventional protein sources (housefly larvae) in their feed. Currently, there have been no references to address the effect of temperature and humidity variations on the growth of local chickens in Niger.

In the same environment of sanitary and food monitoring, the variations of temperature and hygrometry could impact the zootechnical performances of chickens (Ranjan et al., 2019). The objective of the present study was to identify the effects of seasonal variations in temperature and humidity on weight gain and growth curve parameters of local chickens in Niamey, Niger.

MATERIALS AND METHODS

Ethics approval

The data collection was carried out in compliance with the animal welfare and biosecurity established by the Department of Animal Production of the Faculty of Agronomy of the University of Niamey, Niger (AFARNi/FA/DPA-002).

Biological material

The chickens studied were obtained by artificial incubation of eggs from local hens. These local hens were raised at the poultry station of the Faculty of Agronomy of the University of Niamey, Niamey, Niger. The physical and chemical characteristics of the eggs of these parent hens were described based on a study by Guisso Taffa et al. (2022). Both groups in this study were from the same parents. The first group had 96 chicks reared from January to May 2021. The second group entailed 124 chicks that were reared from July to November 2021.

Rearing conditions

Both groups were reared in the same building, with the same feed composition and energy density (Table 1). The feed was in the form of crumbs and distributed *ad libitum*. The rearing building was 11 m long, 5 m wide, and 4.5 m high. Figure 1 shows the interior of the rearing building. For the starter phase (first day to 2 weeks), the chicks were kept under artificial lighting and heating until the second week of age. During this starter phase, lighting was maintained from 8:00 a.m. to 10:00 p.m., and heating was only at night (from 10:00 p.m. to 8:00 a.m.). Figure 2 shows the starter boxes (a) and the chicks during the starter phase (b). During the growth phase, the chickens were reared under natural lighting, and the ambient temperature and humidity of the building were not manipulated. They were recorded daily with a thermo-hygrometer indicating daily maximum and minimum temperatures. The chickens were weighed weekly using a digital dial scale with a precision of one gram. All animals were vaccinated against the two main avian diseases of Newcastle and Gumboro endemic in Niger. Table 2 shows the vaccination protocol that was followed in the current study.

Figure 1. The Interior of the breeding building shows the distribution of the chickens in the cages, with 10 chickens per cage

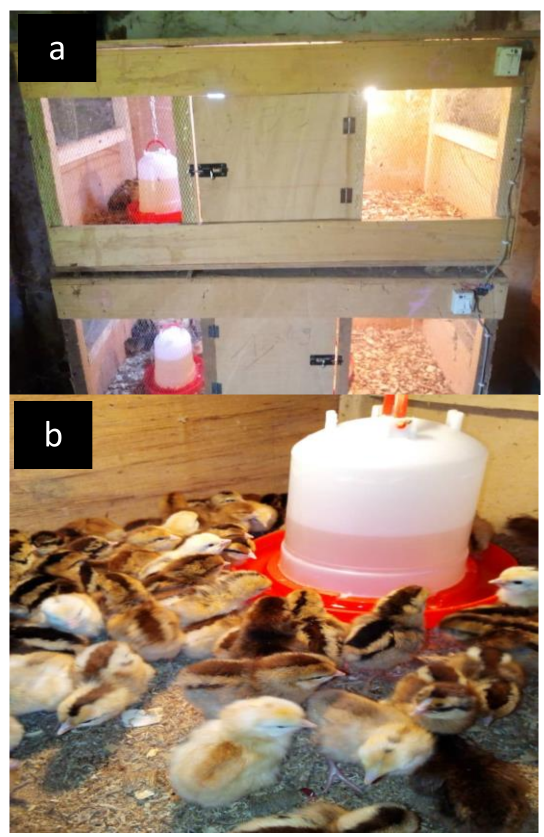

Figure 2. Starter boxes (a) and chicks during the starter phase (b) with lighting and heating system

Table 1. Physical and chemical composition of feeds used for local chickens of Niamey, Niger

Ingredients	Starter (1-14 days)	Grower (15-140 days)
Centesimal composition (%)		
Commercial concentrate *	30	30
Corn	20	20
Wheat Bran	50	50
Analytical composition		
Metabolizable energy (Kcal/kg)	2910.68	2738.70
Dry matter (g/kg)	929	935.9
Fat (g/kg)	65.55	69.56
Mineral matter (g/kg)	73.30	127.47
Ash (g/kg)	10.55	15.49
Crude protein (g/kg)	229.82	172.77
Non-nitrogenous extractives (g/kg)	620.78	614.70

*: An imported commercial feed (Animal Care Services Konsult, Ogere, Nigeria), According to the manufacturer, the essential mineral content of concentrates included a starter (4% Calcium, 4%assimilable phosphorus), and Grower (2.20% Calcium, 1.2% available phosphorus).

Table 2. Vaccination schedule followed during the breeding of the two groups of Niamey's local chickens

Period	Disease	Vaccine	Route
Day 1	Newcastle (NC)	LaSota (Zoetis INC, US)	Oral
Day 5	Gumboro (GB)	Gumboro VAC (Elanco, Netherlands)	Oral
Day 8	Immunization reminder NC	LasSota (Zoetis INC, US	Oral
Day 14	Immunization reminder GB	Avipro Gumboro VAC (Elanco, Netherlands)	Oral
Week 8	Immunization reminder NC	ITA-New (Laprovet, Hungary)	Sub-dermal
Week 16	Immunization reminder NC	ITA-New (Laprovet, Hungary)	Intra-muscular

Each vaccination was accompanied by 3 days of antistress (Introvit A+ or AnimTotal) in the drinking water.

Data analysis and processing

The processing of all data was performed by the free software R project, version 4.1.1 (R project, 2021). The descriptive statistics of the data were performed with the pastecs package, version 1.3.21 (Grosjean et al., 2018).

Analysis of the physical data

Different months were grouped to correctly integrate the temperature and hygrometry data into the multiple linear regression, a grouping of was performed. The aim was to identify seasons with different characteristics regarding temperature and humidity. To do this, the Elbow method, based on the minimization of the sum of squares of deviations (SSwithin), was used to identify the optimal number of groups (DellaData, 2020).

Parameters of the individual growth curve

Non-linear regression using the Gompertz equation was used to determine the parameters of the growth curve of the chickens (Mignon-Grasteau and Beaumont, 2000). These parameters were determined individually for each subject with the package easynls version 5.0 (Arnhold, 2017). The Gompertz equation is as follows:

Yt = Ae^ (-Be^ [-kt])

Yt means weight at time t, A denotes Asymptotic weight, B signifies integration constant, and k is maturation rate.

Multiple regression model

The lm function of the native stats package of the R software was used to evaluate the effects of sex, birth season, and their interaction on hatch weight, monthly weight gains, and growth curve parameters.

The following linear fixed-effects model was used:

$Y_{ijk} = \mu + a_j + b_k + ab_{jk} + \varepsilon_{ijk}$,

Where, Yijk is the hatch weight or monthly body weight gain or one of the growth curve parameters of the ith animal with sex j born in season k; μ denotes the overall mean, aj is the sex fixed effect (j = [1,2]), bk signifies the season fixed effect (k = [season1, season2, season3]), abjk is the sex-season interaction, and εijk accounts for the random residual error.

For each of the models, the significance of the effects of gender and season was identified by comparing the factorial variances to the residual variances using the Fischer test at the significance level $p \leq 0.05$.

RESULTS AND DISCUSSION

Parameters of the growth curves

The parameters of the Gompertz curve were calculated with the weights measured every week. These weights were recorded as P0, P1, P2 up to P20, corresponding to the ages of 1 day (hatching), week 1, week 2, until week 20. Therefore, the estimation is only possible for the two rearing groups and not for the climate clusters. Thus, for both groups, the males had higher parameters than the females (Table 3). In both groups, the asymptotic weight (A), corresponding to the maximum theoretical weight that could be reached, was higher in males, while the maturation rate of females was higher than that of males.

Previous studies have reported results similar to the present study. In the study by Yapi-Gnaore et al. (2011), where chickens were followed from hatching to 22 weeks of age by weighing them every 2 weeks, males of the Forest and Savannah ecotypes had asymptotic weights of 2220 and 2160 g, respectively, compared to 1570 and 1501 g for females of these same ecotypes. In contrast, at the age of 22 weeks for both sexes, the maturation rates of the 'Forest' and Savanna ecotypes were 0.0189 and 0.0200 g/day for males and 0.0199 and 0.0205 g/day for females, respectively.

The higher maturation rate of females than males indicates that females of the local Niamey hen would reach sexual maturity faster than males. This conclusion was also reached in the study of Moula et al. (2009) and N'Dri et al. (2018), who indicated that traditional chicken strains were up to 20 weeks of age for both studies.

Table 3. Growth curves parameters of Niamey's local chickens by sex and group in Niger

Parameters	Female		Male	
	Group1	Group 2	Group 1	Group 2
A (g)	1380.25 ± 25.96	1433.08 ± 71.24	2214.02 ± 69.94	1776.93 ± 63.57
B	3.998 ± 0.048	3.741 ± 0.056	4.359 ± 0.040	3.879 ± 0.043
K (g /day)	0.0191 ± 0.0004	0.0203 ± 0.0006	0.0179 ± 0.0004	0.0199 ± 0.0007

Values are reported as mean ± standard deviation A: Asymptotic weight; B: Integration constant, K: Maturation rate, Group 1: 96 chicken, Group 2: 124 chickens.

Monthly weight gain

Table 4 tabulates the values of hatching weights and monthly weight gains of the local chicken groups in Niamey. The weight at the hatching of the chicks was about 24 g. From week 4, the chicks gain 200 g of weight every month.

The average hatching weight of chicks obtained in this study is similar to those reported by Youssao et al. (2012) and Binda et al. (2012), who studied traditional chickens without sex distinction for chicks. However, those reported by Akouango et al. (2010) and N'Dri et al. (2018) were higher than the present study. Hatching weight is a parameter related to egg weight, which depends on the hen's age and size. Older and heavier hens lay larger eggs (Nys et al., 2018; Travel et al., 2010). Thus, the low weight of the chicks could be explained by the low weight of the local hens.

In relation to monthly weight gains, Binda et al. (2012) simultaneously studied three traditional strains and two commercial broiler chicken strains (Hybro and Hubbar). The traditional strains in their work showed similar monthly weight gains at 4 and 8 weeks as in the present study. However, the monthly weight gains they recorded for the exotic strains were about three times those of the present study. Therefore, it can be deduced that the low growth rate of the local chickens is mainly related to their genetics. In the present study, the chickens were fed *ad libitum* with high nutritional quality and well-balanced feed accompanied by adequate sanitary monitoring and prophylaxis. Thus, the only limiting factor would be the genetic potential of these animals.

Grouping of the months into seasons

The grouping performed allowed us to divide the months into three categories based on ambient temperature and humidity (Table 5).

This division of months into three categories does not correspond perfectly to the natural climate officially recognized in Niger. Indeed, it is reported that in Niger, the rainy season is from June to September and is characterized by heavy rainfall, wind, and a relative drop in temperature. The rest of the year is dry and sunny. The coldest months are from December to February. On the contrary, the months from March to May are the warmest, reaching 45 degrees in the shade with very moderate decreases at night (FAO, 2005). However, the grouping made in this study assigns the month of February to the category of hot and dry months. This difference could be explained by the fact that the temperature and humidity data used to establish this categorization come from a single environment (the experimental site).

Table 4. Descriptive statistics of hatching weight and monthly weight gain of male and female chickens of Niamey

Parameters	Groups	Sex	N	Min	Max	Mean	SEM
P0	1	Male	41	20	30	24.76	0.52
		Female	55	20	30	25	0.49
	2	Male	66	13	30	23.73	0.38
		Female	58	17	31	23.17	0.39
GP_0-4	1	Male	41	70	195	139.07	4.38
		Female	55	12	160	105.31	4.09
	2	Male	66	75	269	184.86	4.71
		Female	58	90	231	172.24	3.57
GP_4-8	1	Male	41	193	338	272.22	5.53
		Female	55	153	278	210.47	4.10
	2	Male	66	102	401	267.39	7.79
		Female	58	110	368	215.95	6.87
GP_8-12	1	Male	41	258	507	391.85	9.93
		Female	55	160	383	286.27	5.87
	2	Male	66	134	470	313.42	7.51
		Female	58	171	571	262.78	9.74
GP_12-16	1	Male	41	170	473	364.05	9.07
		Female	55	108	313	210.98	5.99
	2	Male	66	81	497	302.30	9.89
		Female	58	116	346	205.55	6.70
GP_16-20	1	Male	41	195	475	332.29	10.95
		Female	55	120	344	212.71	6.98
	2	Male	66	133	469	234.94	8.07
		Female	58	112	551	197.21	10.80

N: Number, Min: Minimum; Max: Maximum; SEM: Standard error mean; P0: Weight at hatching; GP_0-4: Weight gain from hatching to week 4; GP_4-8: Weight gain from week 4 to week 8; GP_8-12: Weight gain from week 8 to week 12; GP_12-16: Weight gain from week 12 to week 16; GP_16-20: Weight gain from week 16 to 20

Table 5. Characteristics of the identified seasons

Seasons	T-min (°C)	T-max (°C)	H-min (%)	H-max (%)	Characteristics
1	24.13	41.40	20.14	31.64	Hot and dry
2	27.23	30.40	20.79	49.17	Hot and humid
3	17.24	36.93	19.89	33.07	Cold and dry

T-min: Minimum temperature; T-max: Maximum temperature; H-min: Minimum humidity; H-max: Maximum humidity. Season 1: February, March, April, and May. Season 2: June, July, August, and September Season 3: October, November, December, and January

Table 6. Effects of sex, season, and their interaction on monthly body weight gain and growth curve parameters of Niamey's local chickens

Parameters	Mean ± Standard error	p-values			Adjusted R^2
		Sex	Season	Sex*Season	
P0 (g)	24.17 ± 0.44	0.891 NS	0.001 ***	0.368 NS	0.038
GP_0-4 (g)	105.31 ± 4.29	7.5×10^{-10} ****	2.2×10^{-16} ****	0.016 *	0.496
GP_4-8 (g)	210.47 ± 6.59	3.5×10^{-15} ****	0.928 NS	0.446 NS	0.241
GP_8-12 (g)	286.27 ± 8.31	8.9×10^{-15} ****	1.6×10^{-8} ****	0.001 **	0.337
GP_12-16 (g)	210.98 ± 8.25	2.2×10^{-16} ****	0.00016 ***	0.00087 ***	0.507
GP_16-20	212.71 ± 9.20	4.5×10^{-12} ****	2.3×10^{-8} ****	1.9×10^{-5} ****	0.321
A (g)	1380.20 ± 60.95	4.2×10^{-16} ****	0.0042 **	0.0001 ***	0.310
B	3.998 ± 0.048	7.1×10^{-5} ****	3.6×10^{-12} ****	0.0246 *	0.250
K (g/day)	0.0191 ± 0.0005	0.365 NS	0.00694 **	0.512 NS	0.025

Sex*Season: interaction between sex and season; P0: Weight at hatching, GP_0-4: Weight gain from hatching to week 4, GP_4-8: Weight gain between weeks 4 and 8, GP_8-12: Weight gain between weeks 8 and 12, GP_12-16: Weight gain between weeks 12 and 16, GP_16-20: Weight gain between weeks 16 and 20; A: Asymptotic weight, B: Integration constant, K: Maturation rate; Significance levels (NS: Not significant; *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$; ****: $p < 0.0001$)

Effects of sex and season on growth parameters

The effects of sex, season, and their interaction on monthly body weight gain and growth curve are summarized in Table 6. Except for hatch weight and maturation rate, sex significantly affected all other parameters. The effect of season was non-significant only for body weight gain between weeks 4 and 8 ($p > 0.05$). These results indicated that similar to sex, the rearing period also impacts the growth performance of the local Niamey chicken.

The effect of sex is attributable to the sexual dimorphism in this species. Remeš and Székely (2010) investigated a set of 139 breeds of domestic chickens and reported that, on average, males were 21.5% heavier than females, this difference was even more remarkable (68%) in the red jungle fowl (wild species of chicken), where the male was 68.8% heavier than the female. Furthermore, this dimorphism is under hormonal control, as Johnson (1988) had shown that, in chickens, after one week of age, the concentration of growth hormones in the blood plasma of males was significantly higher than that of females.

The effect of seasons on performance was thought to be a consequence of temperature and humidity variations. Chickens are particularly sensitive to high temperatures, which impacts their feeding behavior and efficiency. The impact on feeding behavior was reflected in decreased feed intake and increased water consumption (Scanes et al., 1984). The body preferentially redirects food energy in the process of homeostasis (Tattersall et al., 2016; Ranjan et al., 2019).

CONCLUSION

The results of this study showed that the growth of local chickens in Niamey is affected by sex and variations in temperature and humidity. Weight gain in males is significantly higher than in females at all ages. The effect of temperature and humidity variation is also present at all ages except from the 4 to 8-week period. In a rural context, the optimal period for rearing these chickens would be from June to January. In experimental conditions, maintaining the temperature between 27-36°C and the ambient humidity between 20-49% would be beneficial to the growth of these chickens in Niger. It would be interesting to complete this study by investigating the reproductive aspects (fertility and hatchability of eggs) in both experimental and rural environments.

DECLARATIONS

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Authors’ contributions

Adamou Guisso Taffa contributed to the conceptualization, investigation, data curation, writing, review, and editing of the manuscript.

Bachir Hamani contributed to the conceptualization, investigation, writing, and review of the manuscript.

Salissou Issa and Nassim Moula contributed to conceptualizing and reviewing the manuscript.

Chaibou Mahamadou and Johann Detilleux were responsible for the conceptualization, resource provision, supervision, and project administration.

All authors have checked and approved the final version of the manuscript for publication in the present journal.

Competing interests

There are no competing interests during this study. The funders were not involved in the study design, data collection, and analysis, nor in the writing of the manuscript.

Ethical considerations

All relevant ethical issues have been checked by all the authors. The authors declared that they presented all data related to this original study in the current manuscript, and the final draft of the manuscript is submitted only to the present journal.

Availability of data and materials

The data of this study are available upon a reasonable request from the corresponding author.

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