2023, Scienceline Publication
World's Veterinary Journal
World Vet J, 13(1): 183-190, March 25, 2023
ISSN 2322-4568
DOI: https://dx.doi.org/10.54203/scil.2023.wvj19

Zootechnical Performance and Growth Curve Modelling of the Niamey Local Chickens in Niger

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ORIGINAL ARTICLE
pii: S232245682300019-13
Received: 24 December 2022
Accepted: 19 February 2023

ABSTRACT

The Niamey region in Niger depends on imports to meet its chicken meat needs. Although consumers appreciate local poultry products, they cannot fulfill their needs. The reluctance of modern producers to use local chickens on their farms is linked to a lack of knowledge of the production characteristics of local strains, which have been little studied. Thus, this study aimed to determine the growth profile of traditional chickens from villages in the Niamey region (Niger). In doing so, 100 local chicks whose parents were collected in the surrounding villages of the Niamey region were followed from hatching until the age of 140 days. The chickens were raised in cages with 10 per compartment of 3 m length and 1.5 m width. Food consumption was recorded daily, and weights were measured weekly. The parameters of the growth curves were obtained using the Gompertz equation. Female and male chickens had a significant weight difference at the third week of age. The mean weight of chicks at hatching was 24.90 ± 0.36 g. At the end of the follow-up, males, with a mean weight of 1523.05 ± 26.22 g were significantly heavier than females (1052.73 ± 14.04 g). Over the entire period of the experiment, the average daily gain and consumption indices were 9.5 g/d and 5.12, respectively. Asymptotic weights were 2096.78 g and 1313.26 g for males and females, respectively. The maturation factor of the Gompertz equation was higher in females (0.0196 g/d) than in males (0.0181 g/d), and the inflection age averaged 75 days for both sexes. In conclusion, Niamey local chickens are slow growing and have a high feed conversion ratio compared to the modern broiler or layer strains.

Keywords: Average daily gain, Feed conversion ratio, Growth curve, Local chicken, Weight gain

INTRODUCTION

In West Africa, chicken meat consumption is highly dependent on imports. Thus, in 2020, the import of chicken meat amounted to 488 tons (FAOSTAT, 2020). The low levels of production partly explain this large import of chicken meat in the traditional production systems (Ayssiwede et al., 2013). The viability of West African poultry farming, therefore, depends on the modernization of production systems through the improvement of their breeding conditions (Moula et al., 2009a) and of genetic potential because it is adapted to African environmental conditions (Keambou et al., 2014), it could replace imported exotic strains if their production performances were improved. Therefore, it is necessary to gain more knowledge about breeders' skills. Indeed, the optimization of food and sanitary behaviors leads to better performance of local chickens than those observed in extensive systems, even if these performances remain lower than those of highly specialized commercial strains that have undergone extreme genetic selection pressure (Youssao et al., 2012; Ndofor-Foleng et al., 2015; Dahloum and Hadjoudj, 2016).

The Niamey region depends on imports for its chicken meat needs. Indeed, local poultry products, although better appreciated, are far from covering consumer demand, especially during religious holiday periods (Assoumane and Ousseini, 2009). This deficit in local chicken meat is linked to the non-use of these local chickens in the modern farms of Niamey. Indeed, the local poultry products available in the markets of the region prepare from the surrounding villages (Mato et al., 2020). The reluctance of modern producers to use local chickens on their farms is linked to the lack of knowledge of the production characteristics of local strains. For these reasons, the productive performance of local chickens is poorly documented in Niger, although they contain 54.7% of Niger's poultry farms (RGAC, 2007).

The research and development program called Improvement of the Poultry Sector of the Niamey Region (PRD-AFARNi) was born in this context. Through a multidisciplinary approach, this program aimed to establish a differentiated local chicken breed with characteristics known and appreciated by local consumers. The present study dealt with the zootechnical aspects of the AFARNi program and aimed to describe the growth characteristics of local salmon-golden plumage chicken in the Niamey region, Niger.

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MATERIALS AND METHODS

Ethical approval

This study has received ethical approval from the Department of Animal Productions, the Faculty of Agronomy, University of Niamey, Niamey, Niger (Authorization N°: AFARNi/FA/DPA-003).

Study site

The study was performed at the experimental farm of the Faculty of Agronomy of the Abdou Moumouni University of Niamey (UAM/N), Niamey, Niger. The livestock building has a dimension of 30 m by 20 m. The sides are wire mesh to perfect the natural circulation of air. The interior of the boxes is lined with a wood-based litter 10 cm thick. Chickens were raised under natural lighting except for the starter period. Cages have been specially designed for the starter phase with dimensions of 2 m length, 1 m width, and 0.8 m height. They were made of plank and mesh and had a lighting and heating system (Figure 1). Lighting and heating are controlled manually through switches. The heating bulb was on during this phase from 6 a.m. to 8 p.m. The relative humidity varied between 40% and 60%, and the temperature inside the cages was maintained between 37 and 38°C.

Figure 1. Cages used for the starter period

Biological material

The chicks monitored in this study were descendants of 65 hens and 22 roosters collected in 8 villages around Niamey. This breeding group was formed based on morphological criteria established during a survey of sellers and consumers in poultry markets in the Niamey region, Niger (Mato et al., 2020). Figures 2 and 3 show the male and female chickens of this study. These chicks were obtained by artificial incubation of 126 eggs collected from the parents. The duration and storage period of the eggs before the beginning of the artificial incubation was 5 days to limit the quality deterioration of the eggs. Incubation lasted about 22 days. A first candling was done after 7 days to eliminate unfertilized eggs, which were 4. The second check was done on day 14 to identify eggs with embryos that had stopped developing. Thus, at the end of the incubation, 108 chicks were hatched, and only 100 were kept for experimentation. The startup phase lasted 4 weeks. For the first two weeks, the chicks were distributed in two cages at a rate of 50 chicks per cage. At the end of the second week, the chicks were distributed in 4 starter cages at a rate of 25 subjects per cage. At the end of the startup period, the non-sexed chicks were randomly distributed into 10 breeding units. The identification was made using plastic rings. In each breeding unit, all the subjects wore rings of different colors. This device made it possible to follow individually the evolution of the weight of each subject and to assign the sex at week 12 of age. Thus, the experimental group consisted of 46 males and 54 females. No mortality was recorded during the experiment.

Figure 2. Red roosters from the Niamey region, Niger

Figure 3. Golden Salmon hens from the Niamey region, Niger

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Feeding and health monitoring

The experiment lasted 20 weeks during which the chickens were weighed every week. The chicks were vaccinated against Newcastle disease (NC) and Gumboro disease (GB), which are endemic avian diseases in Niger. For Newcastle disease, the chicks were vaccinated orally, in the drinking water, at hatching, and a booster at day 8 with LaSota vaccine (Zoetis INC, US). A second vaccination against NC was performed at 8 weeks of age by subcutaneous injection with ITA-New vaccine (Laprovet, Hungary). Vaccination against GB (by drinking water) was done on day 5 after hatching and booster vaccination on day 14 with Gumboror-Vac (Elanco, Netherlands) was performed. The chickens were fed and watered *ad libitum*. Food consumption was measured by the difference between the quantity of distributed food and that food did not consume until the next day. The chickens were fed with 3 types of feed depending on the rearing phase which were the starter, grower, and pre-layer feeds (Table 1). The bromatological composition of these feeds was determined at the animal nutrition laboratory of the Faculty of Agronomy, University of Niamey, Niger. The amounts of non-nitrogen extracts (NNE) and gross (GE) and metabolizable (ME) energies were calculated according to formulas 1, 2, and 3 (Larbier and Leclercq, 1992).

NNE = DM% - (CP% + F%+ CF% + TMM%) (Formula 1)

GE = 57.2%CP + 95.0%F + 47.9%CF + 41.7%NNE (Formula 2)

EM = 0.64GE (Formula 3)

DM: Dry matter; F: Fat; CP: Crude protein; CF: Crude fiber and TMM: Total Mineral matter, GE: Gross energy

Table 1. Bromatological compositions as a percentage of dry matter of food in local chicken of Niamey, Niger

Content	Starter (0 to 28 days)	Grower (28 to 84 days)	Pre-layer (84 to 140 days)
Physical composition			
Corn (%)	50	50	50
Wheat bran (%)	30	30	30
Commercial concentrate[1] (%)	20	20	20
Chemical composition			
Dry matter (%)	92.90	93.59	93.40
Fat[2] (%)	6.09	6.51	4.54
Crude protein[2] (%)	21.35	16.17	16.53
Total mineral matter (ash)[2] (%)	6.81	11.93	10.67
Crude fiber[2] (%)	0.98	1.45	3.72
Non-nitrogenous extract (%)	64.77	63.93	64.54
Gross energy (Kcal/Kg)	4547.94	4279.22	4246.18
Metabolizable energy (Kcal/Kg)	2910.68	2738.70	2717.55

[1]Animal Care Services Konsult, Ogere, Nigeria; [2]Related to dry matter

Statistical analysis

The R software (version 4.0.5) was used for all statistical analyses. The parameters of the Gompertz model (Formula 4) were obtained with the easynls package. This model best describes the growth of *Gallus gallus domesticus* (Darmani Kuhi et al., 2010; Firas Rashad, 2015; Bashiru et al., 2019; Akinsola et al., 2021). The equation is written as follows:

$Y_t = Ae^{(-Be^{(-k_t)})}$ (Formula 4)

Where, the parameter B equals to L/k, Y_t denotes weight at time t in grams, A signifies asymptotic weight (in grams), L determines the specific initial growth rate (g/d), and K is the maturation factor.

The age at the inflection (T_I) is calculated as follows: $T_I = 1/k*\ln|B|$

The average daily gain (ADG) and consumption index (CI) were calculated using the following formulas:

ADG = Weight gain of the period (g) / Number of days in the period (Formula 5)

CI = Food consumption in the week (g) / Weight gain in the same week (g) (Formula 6)

Welch's t-test was used to compare means of ADG, CI, and weights between both sexes. The significance level was set at $p \leq 0.05$.

RESULTS AND DISCUSSION

Growth performance

At hatching, the mean weight of chicks of both sexes was 24.90 ± 0.36 g (mean ± standard error). This hatching weight of the chicks of the Niamey salmon-golden hen is slightly lower than those of the chicks of the ecotypes of local hens of Benin, which ranged from 26.2 to 26.8 g (Youssao et al., 2012). This gap is a little larger between the chicks of Niamey and those of the local hen of Congo, which was 28.38 ± 2.3 g. Despite this discrepancy, the Niamey chicks showed incredible growth during the startup period than the Congo chicks (Akouango et al., 2010). The latter had

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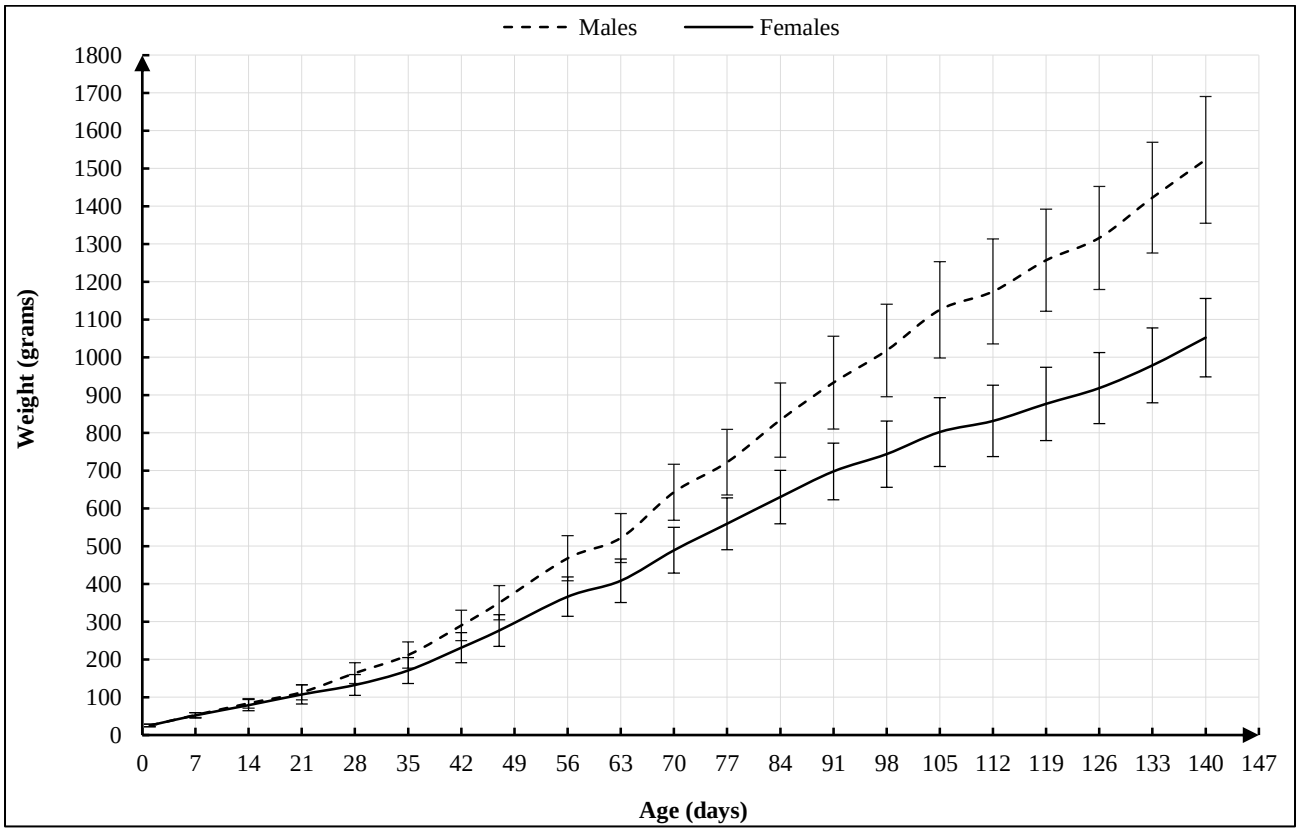
multiplied their weight by 4.2 after one month of rearing, while this ratio was 5.96 for the chicks in the present study. The good growth measured during the startup period in this study would be the result of the high nutritional quality of the feed but also of the breeding environment of the chicks during the startup phase. Indeed, the nutritional balance as well as the appropriate particle size of the food; the adequacy of lighting and heating, allow a better success in chick rearing (Bigot et al., 2001; Laborie et al., 2013; Boussaâda, 2016).

At 140 days of rearing, the males and females in this study weighed 1523.05 ± 26.22 g and 1052.73 ± 14.04 g, respectively. The weights at 140 days of the Niamey chickens were higher than those of the males (1239.36 ± 119 g) and females (897.3 ± 95.54 g) of the local Congolese chicken at the same age (Akouango et al., 2010). A similarity was observed between Niamey chickens and the Forest and Savannah ecotypes of Côte d'Ivoire whose males weighed 1536.8 ± 0.11 g and 1545.1 ± 0.09 g, respectively, and females weighed 1112.0.0 ± 0.12 g and 1089.3 ± 0.12 g at 5 months of age (Yapi-Gnaore et al., 2011). However, for the same age, the weights of the males (1865.13 g) and females (1361.71 g) of the local Kabyle chicken from Algeria were higher than those of the chickens in the present study (Moula et al., 2009b). However, these authors specified that crosses partly explain the high weight of Kabyle chickens with commercial broiler strains carried out by the breeders to increase the production of their chickens. The weights of males and females of the Kolonto ecotype of Niger in rural areas were 1641.2 ± 360 g and 1253.5 ± 275 g (Ousseini et al., 2019). These weights are slightly higher than those obtained in this study. However, it should be noted that the main feature of this Kolonto ecotype is its large size (Ousseini et al., 2020). In this study, the authors reported weight averages of 1484.24 ± 45.86 g for males and 1266.64 ± 45.05 g for females over the entire local chicken population of Niger. These measurements were conducted in rural areas of Gaya region (Dosso-Niger) on subjects whose ages can be well beyond the 140 days to which the present study had limited.

Weight sexual dimorphism

The growth of Niamey chicken follows different curves depending on sex, as shown in Graph 1. In addition, statistical tests revealed significant differences ($p < 0.05$) between males and females beyond the startup phase of the growth. This difference, described as dimorphism, has been identified in several local African strains (Moula et al., 2009b, Ait Kaki and Moula, 2013; N'Dri et al., 2018). This sexual dimorphism always favors males in the species Gallus gallus domesticus and affects weight growth in proportions ranging from 5 to 10% (Mignon-Grasteau and Beaumont, 2000). Such as weight growth, sexual dimorphism is also expressed in other qualitative characteristics called secondary sexual characteristics. For example, sexual dimorphism is expressed through the level of crest development or the appearance of specific colors (Coquerelle, 2000). Thus, it is this sexual dimorphism that explains the difference in plumage color between males and females in this study.



Graph 1. Growth curve of males and females of local chickens in Niamey, Niger, in 2022

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Food valorization

The average daily gain (ADG) and consumption index (CI) values, regardless of gender, were 9.5 g/d and 5.12, respectively. At the $p < 0.05$ threshold, the ADG of roosters (11.56 g/d) was higher than that of hens (7.85 g/d) for the CI, and females had a higher mean (5.87) than males (4.36). The mean ADG of Niamey chicken is higher than those reported by Guédou et al. (2016), which ranged from 5.89 to 6.78 g/d. In contrast, the average ADG in this study is similar to that of the exotic strain (RIR) studied in Ethiopia, which was 8.8 g/d for a rearing period from hatching to 22 weeks (Hassen et al. 2006). The mean CI obtained in this study was slightly lower than those (5.84 to 6.18) of the local chicken from Benin (Guédou et al., 2016). However, the mean CI obtained in this study was comparable to those of local Cameroonian chicken ecotypes that ranged from 4.13 to 5.34 (N'Dri et al., 2018). The local hen of Basse-Kabylie (Algeria) had a consumption index of 7.86 which was much higher than that of the chicken of Niamey (Moula et al., 2009b).

Table 2 shows the weekly evolution of ADG and the CI by sex. For these two parameters, the difference between the sexes was not significant during the first three weeks of rearing ($p > 0.05$); however, for the rest of the time, roosters had significantly higher averages of ADG and CI than hens ($p < 0.05$). The evolution of the ADG has been gradual and nonlinear. However, a substantial increase in CI was observed from day 91 for females and from day 98 for males. This increase in CI at these ages could be partly caused by food waste related to the change in food that occurred on day 84. Indeed, the pre-laying feed had a larger particle size than the grower feed, which could cause animals to look for the intermediate-sized particles they were used to while ejecting the larger particles into the litter. Another explanation would be the triggering of the sexual maturation process of these chickens, which occurs between 18 and 20 weeks of age for the chicken breed of the present study (Guisso Taffa et al., 2022a). Indeed, sexual maturity is a qualitative phenomenon requiring nutrients and energy (Larbier and Leclercq, 1992). This suggests that a part of the consumed food was used for unquantified physiological needs that are not considered in estimating the consumption index.

Thus, the local chicken of Niamey was characterized by a food valorization like that of other strains of local chickens in Africa. The observed performance is partly explained by the genetics of the strain but also by the improvement of the breeding conditions for food and habitat can improve the performance records. Better control when switching from a floury to a coarse food could reduce food waste and thus improve the consumption index during sexual maturation.

Table 2. Average daily gain and consumption index of local salmon-golden chicken in Niamey, Niger, from 7 to 140 days of age

Ages (days)	Average daily gain (g/d) (mean ± SE)		Consumption index (g/g) (mean ± SE)	
	Male	Female	Male	Female
7	3.99 ± 0.11 [a]	3.83 ± 0.13 [a]	1.59 ± 0.05 [a]	1.79 ± 0.14 [a]
14	4.44 ± 0.19 [a]	3.93 ± 0.17 [a]	2.61 ± 0.16 [a]	2.95 ± 0.16 [a]
21	4.18 ± 0.23 [a]	4.33 ± 0.24 [a]	4.89 ± 0.27 [a]	4.60 ± 0.21 [a]
28	8.28 ± 0.67 [a]	5.93 ± 0.50 [b]	3.13 ± 0.25 [a]	3.69 ± 0.23 [a]
35	6.83 ± 0.25 [a]	5.49 ± 0.23 [b]	3.55 ± 0.15 [a]	4.45 ± 0.17 [b]
42	11.20 ± 0.28 [a]	8.62 ± 0.23 [b]	2.52 ± 0.07 [a]	3.32 ± 0.10 [b]
49	8.57 ± 0.32 [a]	6.64 ± 0.23 [b]	3.46 ± 0.14 [a]	4.43 ± 0.14 [b]
56	16.81 ± 0.55 [a]	12.78 ± 0.38 [b]	2.28 ± 0.12 [a]	2.98 ± 0.12 [b]
63	7.98 ± 0.35 [a]	6.47 ± 0.35 [b]	4.91 ± 0.21 [a]	6.01 ± 0.21 [b]
70	17.30 ± 0.64 [a]	11.80 ± 0.34 [b]	2.83 ± 0.13 [a]	4.11 ± 0.15 [b]
77	12.93 ± 0.99 [a]	10.29 ± 0.41 [b]	3.81 ± 0.29 [a]	4.79 ± 0.19 [b]
84	16.45 ± 0.79 [a]	10.10 ± 0.41 [b]	3.17 ± 0.16 [a]	4.82 ± 0.15 [b]
91	15.37 ± 0.84 [a]	9.69 ± 0.47 [b]	3.51 ± 0.20 [a]	5.31 ± 0.22 [b]
98	12.93 ± 0.99 [a]	8.11 ± 0.54 [b]	4.96 ± 0.34 [a]	5.15 ± 0.26 [b]
105	15.77 ± 0.89 [a]	8.73 ± 0.55 [b]	5.28 ± 0.49 [a]	9.97 ± 0.75 [b]
112	9.46 ± 0.85 [a]	6.46 ± 0.54 [b]	8.17 ± 0.66 [a]	10.24 ± 0.63 [b]
119	12.19 ± 0.86 [a]	7.65 ± 0.42 [b]	6.30 ± 0.45 [a]	10.38 ± 0.60 [b]
126	8.94 ± 0.54 [a]	6.40 ± 0.53 [b]	9.59 ± 0.74 [a]	12.96 ± 0.89 [b]
133	15.4 ± 1.16 [a]	9.26 ± 0.60 [b]	6.05 ± 0.56 [a]	9.28 ± 0.75 [b]
140	14.32 ± 0.93 [a]	10.48 ± 0.61 [b]	4.67 ± 0.31 [a]	6.15 ± 0.28 [b]

[a,b] the averages bearing the same superscript letters on the same row are not significantly different at the 5% threshold

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Characteristics of the growth curve

The growth curve parameters estimated between 1 and 140 days are presented in Table 3. The data reported in this Table 3 indicate that in the Niamey chicken, the asymptotic weight (A), age of inflection (TI), and initial specific growth rate (L) of roosters were higher than those of hens. Contrary, the maturation factor (K) of hens was higher than that of roosters. Thus, the general characteristics of the growth curve in the local chicken of Niamey are well in line with the growth characteristics of poultry species marked by sexual dimorphism between males and females (Mignon-Grasteau and Beaumont, 2000).

In comparison with other chicken strains in Africa, the growth curve parameters obtained in this study follow the same trend as those reported by Yapi-Gnaore et al. (2011) on forest and savannah ecotypes in Côte d'Ivoire as well as those of Moula et al. (2009a) on the Kabyle hen in Algeria. The maturation rate (k) of Niamey chicken was lower than that of the chickens studied by N'Dri et al. (2018) and Moula et al. (2009a) but similar to the report of Yapi-Gnaore et al. (2011) and higher than the values reported by Moujahed et al. (2011). These results indicated that Niamey chicken, similar to most African chicken strains, belongs to light strains with slow juvenile growth and maturation compared to highly selected industrial strains (Mignon-Grasteau and Beaumont, 2000; Hassen et al., 2006; Moujahed and Haddad, 2013).

However, the asymptotic weight of the roosters indicates that it is possible to improve their growth by selection and increasing their specific initial growth rate. In addition, Guisso Taffa et al. (2022b) found that selection for growth improvement from 8 weeks of age would give good results for the same chicken strain. The low asymptotic weight of the hens combined with their precocity (high maturation factor) can lead to the production of small size eggs at the beginning of laying. Indeed, the weight of an egg is positively correlated with the age and weight of the hen (Bouvarel et al., 2010). In addition, the precocity of these hens can considerably reduce their growth during the laying phase. Indeed, during the reproductive phase (egg-laying for hens), the female organism preferentially redirects energy and food proteins toward the reproductive process (egg production) at the expense of growth (Whittemore, 2008).

Table 3. Parameters of the growth curve of the local golden salmon chicken in Niamey, Niger

Parameters	Female	Male	Average
A (g)	1313.26	2096.78	1638.06
B	3.91	4.29	4.08
k (g/d)	0.0196	0.0181	0.0188
L (g/d)	0.0765	0.0776	0.0767
T_I (d)	69.69	80.51	74.90

A: Asymptotic weight; B: Integration constant; L: Specific initial growth rate; K: Maturation factor; T_I: Age at the inflection

CONCLUSION

This study is one of the first reports on the growth performance of Niamey chicken in a semi-intensive rearing system. Thus, Niamey chicken exhibited the same growth characteristics as other local African strains. These chickens have a low hatching weight and a high feed conversion ratio due to poor feed conversion. Overall, the results of this study demonstrated that it is possible to improve the growth performance of the local Chicken of Niamey by improving the breeding conditions. Therefore, the use of Niamey's local chicken for profitable production would presuppose an improvement in rearing conditions, then in their consumption index, and later in their weight growth through genetic selection or crossbreeding. With attention to the conditions of hygiene level and farm management in Niger, crossbreeding would be the best way to improve the productivity of local chickens. The interest would be to obtain a hybrid strain that performs well and is acclimatized to the local conditions of Niger. In addition to this study, it would be necessary to conduct other studies to know the reproductive characteristics of this local chicken breed.

DECLARATIONS

Acknowledgments

Authors would like to thank Dr. Ahmet Moustapha, veterinarian, and temporary worker at the Faculty of Agronomy of the University of Niamey, for his help in health monitoring.

Funding

This study is funded by the Belgian Academy of Research and Higher Education (ARES) as part of the research and development project: Improvement of the poultry sector in the Niamey region (AFARNi).

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Authors' contributions

Guisso Taffa Adamou, Salissou Issa, Johann Detilleux, Chaibou Mahamadou, and Nassim Moula participated in the design and planning of the study. Guisso Taffa Adamou and Bachir Hamani collected the data. Guisso Taffa Adamou, Salissou Issa, and Nassim Moula participated in the analysis and interpretation of the data. Guisso Taffa Adamou wrote the first version of the manuscript. Salissou Issa, Chaibou Mahamadou, Johann Detilleux, Nassim Moula, and Bachir Hamani contributed to the critical revision of the manuscript. All authors checked and approved the final draft of the manuscript for submission to the present journal.

Conflict of interests

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of the data; in the writing of the manuscript; or in the decision to publish the results.

Ethical considerations

The authors confirm that all ethical aspects of publishing an original article have been taken into account in the elaboration of this manuscript.

Availability of data and materials

The authors declare that they will be ready to provide all the necessary data upon reasonable request.

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To cite this paper: Guisso Taffa A, Issa S, Bachir H, Mahamadou Ch, Johann D, and Nassim M (2023). Zootechnical Performance and Growth Curve Modelling of the Niamey Local Chickens in Niger. *World Vet. J.*, 13 (1): 183-190. DOI: https://dx.doi.org/10.54203/scil.2023.wvj19

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