International Journal of Ecology and Ecosolution
Vol. 5(2), pp. 18-23, May 2018
ISSN: 2437 - 1327
Full Length Research Paper

Egg production and linear body measurement traits of local and three exotic chicken genotypes reared under two agroecological zones

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Accepted 28 May, 2018

ABSTRACT

This study was conducted to assess egg production, body weight and the linear body measurement traits of exotic breeds (Bovans brown, Koekoeck and Sasso) and local chickens reared in two agroecological zones under traditional management system. For the assessment of the egg production traits, 200 households were randomly selected from lowland and midland agroecologies. Linear body measurement traits were assessed from 192 chickens of the four genotypes drawn from 48 households of two agroecologies. The results indicated that the average age at first egg of all exotic chickens was shorter ($p<0.05$) than that of the local chickens in both agroecologies. The number of eggs per hen per year was 49.1, 134, 117, and 138 for local, Sasso, Bovans brown and Koekoeck genotypes, respectively. The Sasso and Koekoek chicken genotypes raised in the lowland produced the highest ($p<0.05$) egg number/hen/year. The body weight of Sasso, Bovans brown, Koekeok and local chickens reared in the lowland was 3.38, 2.91, 2.79 and 2.05 kg, respectively being ($p<0.05$) different from each other. The Bovans brown and Sasso chickens reared in the midland had higher ($p<0.05$) body length, chest width and wing span values as compared with other chicken genotypes. Among the male chickens, Sasso breeds were superior ($p<0.05$) in body weight, body length, and chest width. In conclusion, the exotic chicken genotypes had a superior advantage over the indigenous chickens in egg production traits as well as body weight and linear body measurements in both agroecologies. Among the exotic genotypes, the Sasso genotype was found to be the best in most performance traits in the lowland agroecology while the Bovans brown and Koekoek genotypes were suitable in the midland agroecologies. Further study is recommended to assess the resistance potentials of exotic chicken breeds against locally available infectious diseases and parasites in both agroecologies.

Keywords: Bovans brown, Koekoek, Sasso, agroecology, linear body measurements, egg production.

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INTRODUCTION

Ethiopia is representative of countries where traditional poultry plays a dominant role in total poultry production which represents an important part of the national economy in general and rural economy in particular (Fiseha et al., 2010; Aberra and Tegene, 2011). In Ethiopia, farmers for whom it may be the only form of savings and their own consumption raise the majority of the chickens under the traditional management system. This poultry production system is characterized by small flock sizes, low input and output, absence of proper housing and feeding, natural incubation and brooding (Aberra and Tegene, 2011; Mesba and Aberra, 2013; Aberra, 2014). Study on the scenario and current chicken production and productivity might be an essential prerequisite to bring the indigenous production system more productive conditions, to develop chicken production strategies and to provide guidelines for policy makers (Fiseha et al., 2010; Fassill et al., 2010; Aberra et al., 2011).

Due to the low production and productivity of African

indigenous chickens, efforts are being made by the district Bureau of Agriculture to introduce some superior tropically adapted chicken genotypes. One of such is the Koekoek chicken, which is a South African breed of chicken developed in the 1950s at the Potchefstroom Agricultural College in the city of Potchefstroom by cross breeding of Black Australorp, White Leghorn, and Barred Plymouth Rock (Fourie and Grobbelaar, 2003). This chicken genotype is also known by a common name of Potchefstroom Koekoek. The name Koekoek refers to the barred colour pattern of the birds. This breed is very popular among rural farmers in South Africa and neighboring countries for egg and meat production (Grobbelaar et al., 2010). The Sasso is another improved tropically adapted chicken genotype, developed in France, and tested in Ghana (Osei-Amponsah et al., 2012) and Nigeria (Yakubu and Ari, 2018). The colour of Sasso chicken is red brown with black tail feather. The other exotic chicken introduced into the study area was Bovans brown, which has excellent genetic potential in free-range environments. It is a brown-feathered bird with white tail feather.

Aman et al. (2017) reported some preliminary results on the reproductive and productive potentials of the Sasso chickens reared at Wolayita and Kembata zones of southern Ethiopia. Moreover, another study conducted by Desalew et al. (2013) reported on the productive performances and egg quality traits of Bovans Brown and Koekoek chickens under village production system in Ada'a and Lume districts of Oromia Regional State in central Ethiopia. However, the egg production potentials, body weight, and linear body measurement traits of these exotic chicken genotypes have not yet systematically been assessed in midland and lowland agroecologies of the study area and thus relevant information is not available. Therefore, this study was conducted to assess the genetic based variations in egg production, body weight, and linear body measurements of exotic and local chickens reared in both contrasting agroecological zones.

MATERIALS AND METHODS

Description of the agroecological zones of the study area

The study was conducted in Boricha district, which is situated at 6°49' 59.99" N and 38°29' 59.99" E in Sidama Zone, southern Ethiopia. The average annual temperature of the study area varies between 21.9 and 25.4°C. The annual rainfall pattern of the study area varies from 27.8 to 28.2 ml. The Boricha district has mainly two agro-ecological zones, the midland with altitude ranging from 1500 to 2000 m above sea level and lowland with less than 1500 m above sea level. Hurni (1998) defined the Ethiopian agroecological zonation as a spatial classification of the landscape into area units with "similar" agricultural and ecological characteristics. There are attributes of such units which determine similarities, among others, such as comparable agroclimatic conditions for annual cropping, perennial crops, similar conditions for livestock raising and comparable land resource conditions such as soil, water or vegetative parameters.

Ecological conditions are usually related to climatic parameters, such as amount of rainfall, rainfall variability, temperature or frost hazard, vegetation characteristics (types and composition), whether natural or man-made vegetation, and finally, soil and water characteristics. Usually, agroecological zonation is used to improve the planning of agricultural development, be it in the field of forestry, field cropping, or for livestock management and improvement (Hurni, 1998). The midland agroecology is characterized by mixed farming systems, which is suitable for crop (both annual and perennial) cultivation and livestock production (cattle, sheep, poultry). The lowland agroecology, however, is predominantly characterized by relatively hot environment with erratic rainfall distributions. Livestock production (cattle, poultry, and goats) and crop cultivation (mainly maize) are also the major agricultural activities.

Assessing of the egg production, body weight and linear measurement traits

To study the egg production characteristics of local and exotic chickens, a multi-stage sampling procedure was used. Accordingly, two agroecologies (midland and lowland) were purposively selected from the district based on their chicken population size and production potentials. Two Peasant Associations (PAs) that rear both local and exotic chickens were then selected purposively from each agroeology. Finally, 200 households (50 households from each PA) were randomly selected from the record list of Animal and Fishery Resources Office of the district. Data on husbandry practices, flock structure, production constraints, flock size and egg production characteristics of chickens were then collected by face-to-face interviewing using a semi-structured questionnaires.

The body weight and linear body measurement of matured age local and exotic chickens were recorded from 192 birds (24 chickens from each breed) of randomly selected 48 households from lowland and midland agroecological zones. Measurements from these chickens were used to collect data on body weight and linear measurement traits. Measurements of the respective linear traits and body weight were taken by using a textile measuring tape (cm) and a hanging spring balance (kg). Data on body weight, chest width, body length, shank length and circumference and wingspan were taken following FAO's descriptor for the characterization of chicken genetic resources (FAO, 2012).

Statistical analysis

Data on quantitative traits were analyzed by two-way ANOVA using GLM (SAS, 2012, ver. 9.4) by fitting the two agroecologies (lowland and midland) and four genotypes (Koekoek, Sasso, Bovans brown and Local) as main effects and the interactions among them. Mean comparisons were conducted using Tukey's Studentized Range (HSD) Test and values were considered significant at $p<0.05$.

The following statistical model was used to analyze the egg production data:

$Y_{ijk} = \mu + A_i + B_j + A_i*B_j + e_{ijk}$, where
Y_{ijk} = the observed k variable in the i^{th} agroecology and j^{th} genotype
μ = overall mean of the observed variables
A_i = effect due to i^{th} agroecology (i = lowland and midland)
B_j = effect due to j^{th} genotype of chickens (j = Koekoek, Sasso, Bovans brown, Local)
A_i*B_j = effect due to interaction between i^{th} agroecology and j^{th} genotype
e_{ijk} = random residual error

The following statistical model was used to analyze the body weight and linear body measurements data:

$Y_{ijk} = \mu + A_i + B_j + A_i*B_j + e_{ijk}$, where

Y_{ijk} = the observed *k* variable in the i^{th} sex and j^{th} genotype
μ = overall mean of the observed variables
A_i = effect due to i^{th} sex of chickens (*i* = male and female)
B_j = effect due to j^{th} genotype of chickens (*j* = Koekoek, Sasso, Bovans brown, Local)
A_i*B_j = effect due to interaction between i^{th} sex and j^{th} genotype
e_{ijk} = random residual error

RESULTS

Egg production characteristics

As indicated in Table 1, the average age at first egg of all exotic chickens was lower ($p<0.05$) than local chickens under both agroecologies. The number of eggs per hen per year was higher ($p<0.05$) for all genotypes reared in the midland than those of the lowland agroecology. The Sasso and Koekoek chicken genotypes reared in lowland produced higher ($p<0.05$) number of eggs per hen per year as compared with other chicken genotypes. However, in the midland there is no significant difference between exotic chicken genotypes in this parameter.

The number of eggs per clutch and length of the clutch was shorter ($p<0.05$) for local chickens than those of the exotic genotypes in both agroecological zones. Except for Koekoek chicken, the number of eggs laid per clutch for the other genotypes was higher ($p<0.05$) in the midland than in the lowland. Numerically, the Koekoek chickens had the highest clutch length followed by Sasso and Bovans brown reared in the lowland. Local chickens and Bovans brown reared in the midland had larger clutch length than the other genotypes reared in the lowland.

Table 1. Egg production characteristics of local and exotic chicken genotypes reared in mid and lowland agroecological zones (Least square means ± SD).

Parameters	Lowland	Midland	P-value for agroecology
Age at first egg laying (d)			
Local	224 ± 27.9[a]	252 ± 39.3[a]	<0.001
Sasso	147 ± 22.2[b]	162 ± 24.6[b]	<0.001
Bovans brown	152 ± 20.3[b]	167 ± 16.0[b]	0.016
Koekoek	148 ± 17.5[b]	184 ± 27.3[b]	0.002
Number of eggs/hen/year			
Local	44.6 ± 12.5[c]	53.7 ± 10.8[b]	<0.001
Sasso	129 ± 24.3[a]	137 ± 20.2[a]	0.064
Bovans brown	103 ± 20.2[b]	144 ± 20.0[a]	<0.001
Koekoek	115 ± 30.6[a]	148 ± 29.0[a]	0.037
Number of eggs/clutch			
Local	12.4 ± 2.4[b]	14.2 ± 2.7[b]	<0.001
Sasso	23.8 ± 2.8[a]	26.0 ± 2.6[a]	<0.001
Bovans brown	23.9 ± 3.6[a]	27.3 ± 1.7[a]	<0.001
Koekoek	24.7 ± 6.8[a]	26.8 ± 3.1[a]	0.462
Length of clutch (d)			
Local	24.7 ± 5.0[b]	28.6 ± 5.4[b]	<0.001
Sasso	29.0 ± 3.3[a]	30.2 ± 3.4[a]	0.053
Bovans brown	28.7 ± 3.4[a]	32.0 ± 2.7[a]	0.002
Koekoek	30.4 ± 7.2[a]	32.7 ± 3.2[a]	0.449

[a-c]Means among genotypes within agroecologies with different superscript letters are significant.

Body weight and linear body measurement traits

The effect of agroecology was significant only for chest width and shank length traits. However, the effect of genotype on all parameters was highly significant (Table 2). The effect of genotype by agroecology interaction was also significant for all traits except for shank circumference. The chest width and shank length of all chickens except the Sasso reared in the midland was higher ($p<0.05$) than those of the lowland. The Sasso chicken genotype reared in the lowland agroecology had higher ($p<0.05$) values in body weight and in all linear body measurement traits (except shank circumference) than those of other chicken genotypes. Both Bovans

Table 2. Effect of agroecology, genotype, and their interactions on body weight (kg) and linear body measurement (cm) traits (Mean±SD).

Agro-ecology	Genotype	Body weight	Body length	Wing span	Chest width	Shank length	SC
Lowland	Bovans brown	2.91 ± 0.3^{b}	37.2 ± 2.0^{b}	36.1 ± 2.1^{b}	28.5 ± 2.0^{b}	6.88 ± 0.5^{b}	5.79 ± 0.5^{a}
	Sasso	3.38 ± 0.4^{a}	41.3 ± 1.8^{a}	38.2 ± 2.2^{a}	34.1 ± 3.0^{a}	7.69 ± 0.5^{a}	5.63 ± 0.5^{a}
	Keokeok	2.79 ± 0.5^{b}	36.0 ± 1.7^{b}	35.4 ± 1.9^{b}	28.9 ± 1.9^{b}	6.71 ± 0.8^{b}	5.77 ± 0.5^{a}
	Local	2.05 ± 0.2^{c}	34.2 ± 1.6^{c}	30.4 ± 1.8^{c}	25.4 ± 1.0^{c}	7.63 ± 0.7^{a}	4.38 ± 0.7^{b}
Midland	Bovans brown	3.13 ± 0.5^{a}	38.9 ± 2.3^{ab}	37.8 ± 1.6^{a}	33.4 ± 2.8^{a}	7.52 ± 0.6	5.42 ± 0.7^{b}
	Sasso	3.19 ± 0.5^{a}	40.0 ± 2.1^{a}	36.4 ± 2.1^{a}	33.3 ± 3.1^{a}	7.63 ± 0.5	5.46 ± 0.6^{ab}
	Keokeok	3.17 ± 0.4^{a}	37.5 ± 1.7^{b}	34.4 ± 1.8^{b}	29.4 ± 2.4^{b}	7.29 ± 0.9	5.92 ± 0.7^{a}
	Local	1.98 ± 0.2^{c}	33.9 ± 2.1^{c}	33.4 ± 2.2^{b}	26.5 ± 1.2^{c}	7.71 ± 1.0	4.46 ± 0.7^{c}
Sources of variation							
Agroecology (AE)		0.1488	0.1425	0.0911	0.0001	0.0035	0.3754
Genotype (G)		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
AE x G		0.0027	0.0002	<.0001	<.0001	0.0401	0.1386

$^{a-c}$Means between genotypes within agroecologies with different superscript letters are significant; SC = shank circumference.

brown and Sasso genotypes reared in the lowland had similar values in body weight and in all other linear body measurement traits. The values of body weight and all linear body traits in exotic chickens were higher ($p<0.05$) than those of local chickens. The Bovans brown and Sasso genotypes reared in the midland had higher ($p<0.05$) chest width and wing span values as compared with the other chicken genotypes.

The effect of sex on body weight and linear body measurement traits of the four chicken genotypes is presented in Table 3. Both sex and genotype significantly affected all the observed traits. However, the effect of sex by genotype interaction was only narrowly significant for shank circumference. For all genotypes, male chickens had higher ($p<0.05$) values for body weight and linear measurement traits than females. Among the male chicken genotypes, Sasso chicken breeds were superior in body weight, body length, and chest width and differed ($p<0.05$) from the other genotypes. On the contrary, local male chickens were inferior ($p<0.05$) in body weight, body length, wind span, chest width and shank circumference traits. Similarly, except for shank length, female local chickens were inferior in all other linear measurement traits as compared to exotic chicken genotypes. The three exotic chicken genotypes did not differ in body weight. However, the Sasso female chickens had higher ($p<0.05$) body length, chest width and shank length values than the other two female exotic chicken genotypes.

DISCUSSION

Egg production

The exotic chickens performed better in most of the production traits (irrespective of the agro ecologies) and may be ascribed to the superior breeding and moderately good adaptation to the agroecologies due to their genetic constitution. However, the numbers of eggs produced (annually) of the native chickens are far below the reports of Aman et al. (2017) and Desalew et al. (2013) from Wolayita and Kembata-Tambaro zones and in East Shewa, respectively. This may be due to the types of husbandry practices provided by the households to the chickens as well as the quality and quantity of the feed available in the respective locations. Hence, the development agents in the study area need to appraise the poultry keepers about improved practices and package of poultry husbandry aimed at poverty alleviation.

The age at maturity of the Sasso chickens were earlier with the shortest age to lay when compared the genotypes studied. These findings are in close agreement with those of Aman et al. (2017) who observed that the Sasso chickens reared at Wolayita and Kembata zones of southern Ethiopia had a shorter age at maturity when compared to the other exotic chicken genotypes. The observations may be partly explained by their enhanced adaptability to the studied agro ecologies, thereby favoring them over the other genotypes of chickens included in this study.

The Bovans brown hens had also a shorter age at maturity when compared to the Koekoek, the findings being in agreement with the observations of those of Desalew et al. (2013). This might be attributed to the smaller size of the Bovans brown when compared to Koekoek chickens of the same age. Thus, requiring low amount of nutrients of their maintenance and thereby attaining the shorter age of maturity with the levels of feed available to them. Moreover, the Bovans brown are better in feed conversion efficiency than the Koekoek

Table 3. Effect of sex on the body weight (kg) and linear body measurement (cm) traits of local and exotic chicken genotypes (Mean±SD).

Sex	Genotype	Body weight	Body length	Wing span	Chest width	Shank length	SC
Male	Bovans brown	3.23 ± 0.4^{b}	39.2 ± 2.0^{b}	37.9 ± 1.5^{a}	31.9 ± 3.5^{b}	7.52 ± 0.6^{b}	5.63 ± 0.5^{a}
	Sasso	3.56 ± 0.5^{a}	41.5 ± 1.9^{a}	38.0 ± 2.3^{a}	34.9 ± 3.3^{a}	7.83 ± 0.5^{ab}	5.81 ± 0.6^{a}
	Koekoek	3.21 ± 0.4^{b}	37.8 ± 1.5^{c}	35.3 ± 1.8^{b}	29.7 ± 2.4^{c}	7.50 ± 0.7^{b}	5.82 ± 0.7^{a}
	Local	2.12 ± 0.2^{c}	34.4 ± 1.8^{d}	33.0 ± 2.5^{c}	26.3 ± 1.5^{d}	8.06 ± 0.7^{a}	4.60 ± 0.7^{b}
Female	Bovans brown	2.80 ± 0.4^{a}	36.8 ± 1.9^{b}	36.1 ± 2.1^{a}	30.0 ± 3.2^{b}	6.88 ± 0.76^{bc}	5.58 ± 0.7^{ab}
	Sasso	3.01 ± 0.3^{a}	39.9 ± 1.8^{a}	36.6 ± 2.1^{a}	32.5 ± 3.2^{a}	7.48 ± 0.48^{a}	5.27 ± 0.4^{b}
	Koekoek	2.75 ± 0.5^{a}	35.6 ± 1.6^{b}	34.4 ± 1.9^{b}	28.7 ± 1.9^{b}	6.50 ± 0.72^{c}	5.88 ± 0.6^{a}
	Local	1.90 ± 0.2^{b}	33.6 ± 1.8^{c}	30.8 ± 2.0^{c}	25.7 ± 0.9^{c}	7.27 ± 0.8^{ab}	4.23 ± 0.6^{c}
Sources of variation							
Genotype (G)		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Sex (S)		<.0001	<.0001	<.0001	0.0001	<.0001	0.0100
G × S		0.1203	0.1300	0.4329	0.3131	0.1166	0.0476

$^{a-c}$Means between genotypes within sex groups with different superscript letters are significant; SC = shank circumference.

chickens. This may be because the Bovans brown are hybrids while the Koekoek is a synthetic breed that has been stabilized over decades.

The numbers of eggs laid annually per clutch of the local chickens was in accordance with the result of Alem (2014). However, the numbers of eggs per clutch of the exotic chickens were fewer than Rhode Island Red (RIR) chickens as reported by Alem (2014). This might be explained by the fact that synthetic breeds and hybrids require a better management and quality and quantity of feed for the expression of their genetic potentials. The numbers of annual eggs laid by Sasso, Bovans brown, Koekoek and local chickens were lower than what Aman et al. (2017) and Dessalew et al. (2013) reported which may also be attributed to suboptimal management, age of the chickens and feed availability of the chickens in the areas studied.

Body weight and linear body measurement traits

Body weight and linear body measurements are of economic importance in livestock classification, evaluation and improvement (Deneke et al., 2014). Where there is no information on the genetic parameters of chicken, the use of linear body measurement traits may be a better alternative and may be selected jointly to improve the body weight in the three genotypes investigated. The body weight of the three exotic genotypes was higher as compared with the local chickens, which is in good agreement with the reports of Osei-Amponsah et al. (2011) which indicates absence of systematic selection pressure on the local chickens for many generations.

All the linear measurement traits were higher among the Sasso chickens reared in the lowlands, which suggest that this genotype is better adapted to the lowland agroecological zone due to its genetic potentials being selected for free-range production system. The Bovans brown and Koekoek genotypes performed better in the midlands indicating their suitability to that agroecological zone, which accords with the observations of Ermias (2015). This may be due to the type of feed available in the area as well suitable environmental conditions which would have enabled them to express their genetic potential better than the other genotypes. The present findings are also in close accordance with the reports of Sonaiya and Swan (2004) which indicated a correlation between the amount of feed available and the numbers of eggs produced.

The shank circumference was similar between the three exotic genotypes reared in the lowland agroecology, which suggests their suitability for meat production as compared with the local chickens, which had the lowest value for this trait. The body weight of Sasso chickens was in accordance with the result of Aman et al. (2017). However, the body weight of the Bovans brown and Koekoek hens were higher than the findings of Desalew et al. (2013). The chest width, shank length and body weight of matured local chickens were also higher than those reported by Nigussie et al. (2010). Such differences might be attributed to the age and type of the chicken breed studied as well as the season where the data were collected, which again affects the availability of scavangable feed resources.

The current study has further indicated that the male Sasso chicken genotypes were better in body weight, body length and chest width parameters which suggests that males of this breed might be much suitable for meat production in both agroecological zones. The observed large shank length along with the lowest circumference in male local chickens indicates that they may not be

regarded as meat birds. Among the female genotypes, still the Sasso genotype had the best body weight, body length and chest width qualities as compared with the other breeds.

CONCLUSION

Sasso chicken demonstrated higher egg production, body weight, and linear body measurements in the lowland agroecology while these values were higher among the Bovans brown and Koekoek genotypes at the midlands. From the present study, the Sasso chicken can be further used by the farmers in the lowland while Bovans brown and Koekoek genotypes in the midland agroecology. Further study is recommended to assess the resistance potentials of these exotic chicken genotypes against locally available infectious diseases and parasites in both agroecological zones.

ACKNOWLEDGEMENTS

The authors express their appreciation to the Boricha District Agricultural Office for their unreserved technical support provided during the course of this study. We are further very much grateful to all households for their kind cooperation by allowing us to take all linear measurements on their animals. Ministry of Education and NORAD are acknowledged for providing the required research fund.

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Citation: Assefa S, Melesse A, Banerjee S, 2018. Egg production and linear body measurement traits of local and three exotic chicken genotypes reared under two agroecological zones. Int J Ecol Ecosolution, 5(2): 18-23.