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Evaluation of the Egg Production Performance in Bovans Brown and Koekoek Chicken Breeds under Varied Seasons and Feeding Regimes in South Wollo Zone, Ethiopia

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Abstract: Three-month old 60 pullets and 12 cockerels assigned to a 2X2X3 factorial arrangement as a completely randomized design with 4 treatments of 3 replicate for each treatment, distributed to 12 household farmers and maintained till 15-month age in Kedida Village-South Wollo zone, Ethiopia; in-order to study the effect of season (cold-CS, hot-HSe and main rainy seasons-MRS) and feeding regime (Supplemented-S and Non-supplemented-NS) on egg production performance of Bovans Brown (BB) and Koekoek (Kk) chicken breeds. The result revealed significantly ($P<0.05$) higher total collected eggs (TCE) in Kk and average egg weight (AEW) in BB breed. There were no significant differences in egg mass (EM) among all main and interaction effects. Though insignificant Kk chicken attained 6 days earlier in the age at onset of egg laying (AOEL) and significantly ($P<0.05$) earlier AOEL was recorded in the main effect supplemented and the interaction effects of BB breeds due to supplementation. In TCE-Kk and in AEW-BB breeds main effect was more pronounced than the rest of the two and three-way interaction effects. The result of the present study showed that Kk chicken are well adapted to semi-arid conditions in Ethiopia and their production performance was better than the BB chicken indicating that it is a good choice for egg producers who can regularly supply supplementary feed. Besides, farmers may opt for the Kk breed because of their lower mortality, plumage colour and overall conformation. However, the higher mortality due to unidentified diseases could be one of the reasons for the poor egg production performance of the temperate BB chicken.

Key words: Chicken breed · Egg production · Main effects · Interaction effects · Season · Supplemented and non-supplemented

INTRODUCTION

Tropical and developing countries often rely on exotic germplasm for breeding purposes. They however have climatic conditions, production systems and markets different from those where animals were evaluated. Thus, the Genotype by Environment (G×E) interaction can cause a reduced efficiency of their genetic improvement programs. Genotype by environment interaction is usually described as a situation in which different genotypes (breeds, lines, or strains) respond differently to different environments [1]. With the rapid development of the poultry industry worldwide, especially in developing countries, importation of temperate-zone high-performance stocks to hot regions is on the rise. The adaptability of the exotic breeds under the climate of tropical areas is a great problem for their susceptibility to heat and diseases than the local chickens. The environmental conditions under which poultry are kept and imbalanced diets do not permit to express the full genetic potentials of exotic breeds. Therefore, a suitable stock is necessary that will thrive well under all existing natural hazards in the rural free range condition [2].

Different breeds of exotic chicken (Rhode Island Red, White Leghorns, Bovans Brown, Potchefstroom Koekoek, etc) have been distributed to rural farm households in the study district by the Ministry of Agriculture and NGOs. Among the exotic breeds, Bovans Brown-a temperate egg layer breed developed in Europe and Potchefstroom Koekoek-a South African chicken breed, was included

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under this study. Apparently, there are several evidences that the exotic birds that are known for their good performances elsewhere are always not found to be the best in all the climatic conditions as they require stringent management conditions for their optimum performances. The present study was therefore, undertaken to evaluate the effect of 8seasons and feeding regimes on the egg production performance in Bovans Brown and Koekoek chicken breeds.

MATERIALS AND METHODS

Experimental Site: The research was conducted in Kedida village of Kalu district, South Wollo Zone-Ethiopia; located 375 Km north East of Addis Ababa, with an altitude ranges of 1810 to 1839 m and average temperatures ranging between 12.5 to 18.15°C. The area receives average annual rain fall (RF) ranging from 750 to 900mm (Archives of Kalu district Agriculture Office).

Experimental Design: The experiment was arranged as 2X2X3 factorial in CRD involving two breeds (BB and Kk), two feeding regimes (Supplement with Scavenging-S and Left to scavenge only or Non-Supplemented-NS) and three seasons (Hot Season-HSe, Main Rainy Season-MRS and Cold Season-CS). The treatment combinations are illustrated in Table 1.

Table 1: Treatment Combinations

Factors and levels	Treatments	1	2	3	4
Breed (Br)	Bovans Brown (BB)	+	+		
	Koekoek (Kk)			+	+
Feeding Regime (FR)	Supplemented (S)	+		+	
	Non-Supplemented		+		+
Season (Se)	Hot Season (HSe)	+	+	+	+
	Main Rainy Season (MRS)	+	+	+	+
	Cold Season (CS)	+	+	+	+

Animals and Management: Five pullets and one cockerel at the age of three months were distributed to each of 12 households making a total of 60 pullets and 12 cockerels for the whole experiment. Of the 60 pullets, 30 were BB and 30 Kk; and from 12 cockerels a half was BB and the rest Kk. Commercial feed with nutritional specification (Table 2) of 16/16.5% CP and 2750/2800 Kcal/Kg of feed ME for growers and layers respectively was supplemented to treatments 1 and 3; with 45g during 3-5 and 60g during 5-15 months of age per bird per day which was offered twice daily. The rest two-2 and 4 treatments left to scavenge only. For all age groups vitamins, minerals and amino acid supplements were incorporated in the drinking water according to the manufacturer's recommendation and water was provided *ad libitum*. The feed was purchased from Kombolcha Poultry Multiplication Centre, as well as Dessie and Mekelle private poultry farms.

Data Collection: The data included total collected eggs (TCE), average egg weight (AEW), egg mass (EM) and age at onset of egg laying (AOEL); collected for a period of 9-months (between April 20/2014 and January 13/2015). Average egg weight and EM were determined at sexual maturity, at 40 weeks of age and at the end of the experiment. The age at first egg within each of the treatment determined AOEL. Eggs were collected from each of the households daily on group basis.

Table 2: Nutrient composition of commercial feed used for growers and layers during the experimental period.

Diet	Growers	Layers
Age (months)	3-5	5-15
Nutrients		
Crude Protein (%)	16	16.5
Crude Fiber (%)	5	5.3
Metabolizable energy (Kcal/Kg)	2750	2800
Crude Fat (%)	3.5	7
Crude Ash (%)	6.5	12.5
Methionine (%)	0.35	0.39
Lysine (%)	0.78	0.8
av Phosphorus (%)	0.45	0.35
Sodium (%)	0.15	0.19
Calcium (%)	2.2	4.2
Added Vitamins per Kg of feed		
Vitamin A, IU	10000	12000
Vitamin D3, IU	2500	2500
Vitamin E, mg	25	20

Data Analysis: The data analysis was done with [3] procedures with the General Linear Model (GLM) including the main effects of breed, feeding regime and season and all two and three-way interactions. Least squares means (LSM) were used for mean comparisons and Tukey's Studentized Range (HSD) Test was conducted to separate the means. The process employed the following model:

$$Y_{ijk} = \mu + c_i + d_j + (cd)_{ij} + e_k + (ce)_{ik} + (de)_{jk} + (cde)_{ijk} + e_{ijk}$$

Where: Y_{ijk}=The observation taken at the i^{th} breed, j^{th} feeding regime and k^{th} season, μ=The overall mean of the population for Y_{ijk}, c_i=The effect due to the i^{th} breed, d_j=The effect due to the j^{th} feeding regime, e_k=The effect due to the k^{th} season, $(cd)_{ij}$=The effect due to interaction between the i^{th} breed and the j^{th} feeding regime, $(ce)_{ik}$=The effect due to the interaction between the i^{th} breed and the k^{th} season, $(de)_{jk}$=The effect due to the interaction between the j^{th} feeding regime and k^{th} season, $(cde)_{ijk}$=The effect due to the interaction between i^{th} breed, j^{th} feeding regime and k^{th} season, e_{ijk}=Random error associated with the observation Y_{ijk}

RESULTS AND DISCUSSIONS

The detail results of the egg production traits are presented in the ANOVA Table 3; and LSM and SEM of the main effects in Table 4 and the interaction effects in Tables 5 and 6.

Egg production is a composite of at least the following four traits: total collected eggs-TCE, average egg weight-AEW, egg mass-EM and age at onset of egg laying-AOEL.

Table 3: Summary of the ANOVA for the effects of Br, Se, FR and the interaction effects of Br*FR, Br*Se, FR*Se and Br*Se*FR on egg production traits.

	Mean Squares							
Dependent Variable	Br	FR	Se	Br*FR	Br*Se	FR*Se	Br*Se*FR	Error
TCE	9539*	2147	1111	900	822	83	1081	706
AEW	1069*	2.45	12.07	0.81	3.52	9.51	3.16	9.24
EM	2020188	7169899	5269191	1934881	1661359	102624	2229984	1827472
AOEL	108	481*	----	56	----	----	----	29

*Significantly different at $p<0.05$; Br-Breed, Se-Season, FR-Feeding regime, Br*FR-Breed by feeding regime interaction, Br*Se- Breed by Season interaction, FR*Se-Feeding regime by season interaction, Br*Se*FR- breed by season by feeding regime interaction.

Table 4: LSM and SEM values for the main effects of Br, Se, FR on egg production traits.

Dependent Variable	1. LSM 2. SEM	Br: BB	Br: Kk	FR: S	FR: NS	Se: HSe	Se: MRS	Se: CS
TCE	1	87b	119a	111a	95a	92a	108a	108a
	2	6.89	6.18	8.26	6.45	8.04	10.34	9.07
AEW	1	53.3a	42.4b	47.6a	48.1a	47.40a	47.16a	49a
	2	0.53	0.8	1.45	1.51	2.05	1.86	1.54
EM	1	4694a	5167a	5377a	4484a	5006a	4233a	5552a
	2	393.59	280.57	359.04	296.46	428.67	390.72	375.03
AOEL	1	194a	188a	185b	197a	---	---	----
	2	4.21	2.81	2.95	2.13	---	---	----

- Means with different subscript are significantly different from each other within the main effects. LSM-Least squares means, SEM-Standard Error of the Mean; there is no season effect on AOEL

Table 5: Least Squares Means and Standard Error for Mean values for the interaction effects of Br*FR, Br*Se and FR*Se on egg production traits

			Dependent Variable							
			TCE		AEW		EM		AOEL	
2-way interactions			LSM	SEM	LSM	SEM	LSM	SEM	LSM	SEM
Br*FR	BB	S	99ab	8.14	52.89a	0.77	5372a	468.83	185b	1.67
		NS	74b	9.73	53.71a	0.75	4016a	568.86	202a	3.71
	Kk	S	122a	8.86	42.28b	1.46	5382a	392.08	184b	4.37
		NS	116a	9.04	42.51b	0.77	4953a	411.5	192ab	1.73
Br*Se	BB	CS	101ab	13.2	54.45a	1.32	5744a	767.23	----	----
		HSe	85ab	9.4	53.38a	0.56	4259a	490.82	----	----
		MRS	73b	11.95	52.07a	0.49	3808a	606.22	----	----
	Kk	CS	116ab	9.49	43.55b	2.22	5361a	452.97	----	----
		HSe	132a	12.81	41.40b	0.78	5483a	583.03	----	----
		MRS	110ab	9.19	42.25b	0.71	4659a	422.88	----	----
FR*Se	S	CS	113a	5.9	47.72a	3.45	5934a	459.15	----	----
		HSe	117a	15.22	47.55a	2.77	5411a	526.9	----	----
		MRS	102a	11.52	47.50a	1.96	4786a	525.16	----	----
	NS	CS	104a	15.51	50.28a	2.45	5170a	734.41	----	----
		HSe	100a	14.51	47.23a	2.76	4601a	573.23	----	----
		MRS	82a	13.75	46.82a	2.55	3681a	470.16	----	----

- Means with different subscript are significantly different from each other within the two-way interaction effects.

Table 6: LSM and SEM values for the interaction effects of Br*FR*Se on egg production traits

				Dependent Variable					
				TCE		AEW		EM	
3-way interaction				LSM	SEM	LSM	SEM	LSM	SEM
Br*FR*Se	BB	S	CS	119ab	6.69	53.47ab	2.07	6752a	231
			HSe	88ab	9.07	53.5ab	1.19	4705a	478
			MRS	90ab	19.06	51.7abc	0.57	4658a	963
		NS	CS	83ab	22.28	55.43a	1.86	4736a	1369
			HSe	82ab	18.72	53.27ab	0.35	4353a	972
			MRS	56b	7.86	52.43ab	0.87	2957a	432
Kk	S	CS	107ab	9.54	41.97ab	4.7	5117a	577	
			HSe	145a	15.96	41.6d	1.2	6116a	814
			MRS	113ab	13.12	43.3cd	1.07	4913a	660
		NS	CS	124ab	16.92	45.13bcd	0.24	5604a	796
			HSe	118ab	19.47	41.2d	1.25	4849a	798
			MRS	107ab	15.52	41.2d	0.53	4405a	628

- Means with different subscript are significantly different from each other within the three-way interaction effect.

Total Collected Eggs (TCE): The present study noted significantly ($P<0.05$) highest TCE in Kk breed from the main and Kk*S, Kk*HSe, S*HSe and Kk*S*HSe from the interaction effects. On breed effect, unlike the present study [4] found no significant effect of breed on egg production while [5] reported significant effect of breed on egg production. In addition, this result is in consistence with that of Mwalusanya *et al*. [6] in which results from analyses of variance indicates the existence of significant differences between ecotypes with respect to egg number ($P < 0.05$). There is also a variation even in the same Kk breed between this study which recorded 119 TCE in about 9-months egg production period and 195.9 eggs per year reported by Grobbelaar *et al*. [7]. Indeed, the mean TCE of this study (103eggs in 9 months) is lower than Adami-Tulu research centre (159.9±10.7) as Tesfa *et al*. [8] reported; water shed area of North Ethiopia (144 ±6.97) as Abraham and Yayneshet [9] reported and then at Chittagong Government Veterinary college Pahatali (140.7) as Khan *et al*. [10] reported due to different feeding, climate and production period.

Genetic variation in egg production as revealed in this study could be attributed to differences in environmental factors because numerically higher mortality (0.94) was recorded in the temperate region BB chicken; though the birds were of the same age, reared under the same family production system and subjected to the same management practices except the variation in feeding regime. Besides, the rearing process could be one of the reasons for the variation in egg number with in the same Kk chicken.

In the present finding; Kk and BB both supplemented improved TCE by 6 and 25 eggs respectively (Table 5), which was similar with results reported by Guèye [11] where egg production was improved by feed supplementation. Besides, the following authors presented similar reports. The mean egg number for free range local chickens supplemented with homemade feed and commercial was 31.9 and 31.8, respectively; whereas it was 20.4 for the un-supplemented free range chickens [12]. Total egg production/hen/year of local hens, under existing farmers' management condition was calculated and estimated to be 51.6 eggs and the average number of eggs laid by supplemented local hen per a six months laying period were 50.78 and 51.79 eggs for the first and second years, respectively [13].

Further, the interaction between breed with season showed higher TCE (132) in the Kk*HSe birds followed by 116 during the CS and 110 during the MRS in the same breed. The reason for such variation could be the higher mortality in the BB, in which they produced 101TCE noted during the CS. This two-way interaction showed breed effect is more pronounced in TCE than season effect. Significantly ($p<0.05$) higher TCE noted during the CS in the BB and during the HSe in the Kk breed could be attributed to differences in their origin, the temperate BB breed showed better egg production performance during the CS and the tropical Kk breed during the HSe.

The interaction between FR with season showed higher TCE of 117, 113 and 102 in the HSe, CS and MRS, respectively; on those supplemented birds. This interaction indicates TCE is more affected by supplementation than season.

In regard to 3-way interaction effects, 145 TCE in Kk*S*HSe birds could be due to the higher mortality in the BB which might reduce the TCE to 119 eggs (Table 6).

The two breeds recorded higher TCE both due to supplementation but in different seasons, the BB in the CS and the Kk in the HSe. As mention earlier the origin of the breeds could be the reason for such variation.

Two and three-way interactions effects, except the interaction between breed and FR, on TCE is very scanty to compare the present study with others.

Average Egg Weight (AEW): Average egg weight was significantly ($p<0.05$) higher in BB breed main effect and BB*S, BB*NS, BB in all seasons and BB*NS*CS interaction groups. This study clearly observed breed effect is more pronounced in AEW than the rest of the factors i.e. BB was superior in breed main effect and in all the interaction effects. This might be due to the breed types; BB is an egg type breed with higher EW, compared to the dual purpose Kk having smaller EW.

Compared to the previous study, the value obtained in the Koekoek breed (42.4g) for AEW is very close to that of 42g given by Mwalusanya *et al*. [6] for medium ecotype of Tanzania, 42.5 g given by Ramlah [14] for local chickens of Malaysia using semi-intensive system, around 40g given by Alemu [15] for local chickens of Ethiopia. But lower than 55.7g an average egg weight values of Potchefstroom Koekoek reported by Nthimo [16], 48.9 g reported by Nhleko *et al*. [17] in South Africa indigenous chickens, 46.0g reported by Ramlah [14] in Malaysia local chickens using intensive system and 52.73±0.29 g reported by Yakubu *et al*. [5] for BB breed; and higher than 36.8g reported by Adetayo and Babafunso [18] in Nigeria indigenous chickens kept in cages, 36.27g reported by Ershad [19] in Bangladesh native hen in the field level. The value (53.3g) for AEW of the BB breed obtained in this study is very close to that of 52.73±0.29ggiven by Yakubu *et al*. [5]; but lower than 63.5g obtained from the guideline published by the company and 63.9g reported by Anderson [20] for the same BB breed.

Besides, Mwalusanya *et al.* [6] reported that significant differences ($P<0.01$) were observed among the three strains and control populations with respect to egg weight. The IWK strain (one of the commercial strain of White Leghorns developed by CARI, Izatnagar-India) had significantly higher egg weight (53.89 ± 0.43 g) when measured from other two strains and control population.

Egg Mass (EM): The insignificant difference between breeds, FR, seasons and their two and three way interactions on the EM measured could be due to the fact that the lower TCE (87) of the BB breed was compensated by their higher AEW (53.3g); and the higher TCE (119) of the Kk breed was compensated by their lower AEW (42.4g). Though not significant mortality was higher in the BB and this could be one of the reasons for the lower TCE and EM in this breed.

This result is in agreement with that conducted by Hanan and Gehan [21] who found overall egg mass of this study's Lohman brown hens was more, but not significantly more than that of the Lohman LSL but disagrees with the result obtained by Bonekamp *et al.* [22] who reported daily egg mass production increased significantly ($P<0.05$) with increasing balanced protein; with the findings of Grobas *et al*. [23] who compared production performance of ISA-Brown hens with Dekalb Delta, a White Leghorn egg layer strain and found that egg mass from ISA-Brown was more than that from Dekalb Delta. On the other hand, the average EM of 4931g reported in this work is much lower than 11790±544.50g reported by Agu *et al*. [24] for the breeding groups; lower than 7.2 Kg/hen reported by Solomon [25] for the mean annual EM of the leghorn hens; is close to that of 5600g reported by Nwosu [26] for the light ecotype chicken in south east Nigeria and higher than 1.8Kg/hen reported by Solomon [25] for the mean annual EM of the local hens.

Age at Onset of Egg Laying (AOEL): Though insignificant the Kk chickens attained 6 days earlier in AOEL and significantly ($P<0.05$) earlier AOEL was recorded in the main effect supplemented and the interaction effects of BB breed due to supplementation. The insignificant difference of AOEL between breeds found in this study is supported by many research workers [7, 25 and 16]. Further, this result is in harmony with previous results reported by Barua *et al*. [2] which indicated that Fayomi attained sexual maturity at an earlier age followed by Fyomi*RIR and RIR. It has been also well documented by Gunaratne *et al.* [27] and Gezahegn [28] that village chickens are characterized by late maturity; and the majority of the birds (above 50%) starting laying late at 7-8 months of age by Lulseged, [29].

But, the report of Farooq *et al*. [30] on commercial laying hens showed earlier average age at-first-of lay to be 126±1.02 days and according to Petek [31] commercial egg type layers started laying eggs at the age of 20-21 weeks and produced 277 eggs till 72nd week of their production cycle. The present result showed more delayed sexual maturity i.e. overall AOEL of the two breeds was 191±2.58 days. This could be due to the variation of breed and intensive management. The sexual maturity (production of first egg) found by Grobbelaar *et al*. [7], who stated that the sexual maturity for the Potchefstroom Koekoek was 138.5 days is in contradiction with the 188 days AOEL of the Kk chicken observed in the present study. The difference between the results in more delayed sexual maturity obtained during this investigation and the results obtained by the above authors could be attributed to various factors such as the rearing process.

Regarding the main effect of feed supplementation, this study is in agreement with that conducted by Barua *et al*. [2]who found in age at sexual maturity birds fed extra feed to scavenging had significantly better performance than those without extra feed group ($P<0.05$). A significant ($P<0.05$) improvement of 17days AOEL was noted between the interaction effect BB*supplemented and BB*non-supplemented birds (Table 5) but no significant difference observed between supplemented and non-supplemented Koekoek breed. Similarly, [25] reported that in a trial conducted in Ethiopia the comparative egg production performance of local Ethiopian hens and White Leghorn hens under rural household conditions, a combination of rural household conditions plus 50 g of commercial supplementary feed and intensive conditions, the mean days to sexual maturity for the White Leghorn were 165, 158 and 149 days, respectively and for the local were 169, 158 and 149 days, respectively.

CONCLUSION

The results demonstrated that TCE was higher and early AOEL was attained in the Kk chickens, though higher AEW was recorded in the BB chicken. Earlier AOEL was recorded in the main effect supplemented birds. The insignificant difference in EM in all main and interaction effects could be due to the higher TCE in the Kk and the higher AEW in the BB chickens. However, in TCE-Kk and in AEW-BB breeds main effect was more pronounced than the rest of the two and three-way interaction effects; while supplementation showed early AOEL performance in supplemented compared the non-supplemented groups of BB chickens. The result of the present study showed that Kk chicken are well adapted to semi-arid Ethiopian conditions and their production performance was better than the BB chicken indicating that it is a good choice for egg production under regular supply of supplementary feed. Besides, farmers may opt for the Kk breed because of their lower mortality, plumage colour and overall conformation. Higher mortality due to unidentified diseases could be one of the reasons for the poor production performance of the temperate BB chicken observed in the current study.

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