CHAPTER 2

Effect of restricted feeding and season on the growth performance of Koekoek chickens

Abstract

The main objective of this study was to determine the effects of restricted feeding and season on growth performance of Koekoek chickens. Two hundred and seventy Koekoek chickens were randomly allocated to four feeding level treatments in a completely randomized factorial design. The deep litter system was used. The four treatments were AA (full feeding throughout the study), AR (full feeding for rearing and feed restriction for laying, RA (feed restriction for rearing and full feeding for laying phase) and RR (restricted feeding throughout the study). The data was subjected to the General Linear Model procedure of Statistical Package for Social Sciences (SPSS 17.00). The study was done in summer and winter for 32 weeks per season. The final body weights of Koekoek chickens in the rearing phase were 1.58, 1.58, 1.19 and 1.19 kg in AA, AR, RA and RR treatments respectively. The total weight gains during the rearing for birds that were in AA, AR, RA and RR treatments were 917.8, 924.9, 529.4 and 537.4g respectively. The feed intake of chickens that were full-fed (AA and AR) was 83g/day while for restricted fed birds (RA and RR) it was 58g/day. The average feed conversion ratios in the rearing phase were 5.5, 5.4, 6.79 and 6.7 for chickens in AA, AR, RA and RR treatments respectively. During the laying phase, final body weights of chickens in AA, AR, RA and RR treatments were 2.4, 1.8, 2.6 and 1.9kg respectively. Chickens under RA treatment gained 1126g followed by birds under AA, RR and AR treatments that gained 721.7, 501.9 and 164.6g respectively. The feed conversion ratio of chickens under AA, AR, RA and RR treatments were 15, 46.3, 9.4 and 15.8 respectively. Mortality observed in AA, AR, RA and RR treatments were 2.5, 1.6, 1.6 and 1.9% respectively. Chickens that were subjected to summer performed better in weight for age, average weight gain and feed conversion ratio. The total feed intake and the number of chicken deaths were higher in winter.

Key words: Koekoek chickens, feed restriction, full-fed, season, temperature weight gain, feed intake, feed conversion ratio, mortality rate.

2.1 Introduction

The current price spike in Agricultural commodities especially cereals caused by among other things climate change has significantly contributed to the higher cost of livestock feeds. This increase in the cost of animal feeds makes it difficult for the poor farmers in the rural areas to rear chickens as chicken diet is largely based on grains. In an effort to reduce the increased feeding costs one of the management strategies that could be employed is feed restriction. Restricted feeding has been reported to improve the feed utilization efficiency in chickens (Banalve, 1984). Crounch *et a*l. (2002a) reported that quantitative feed restriction reduces the body weight and feed consumption of Large White turkeys without necessarily affecting the egg production. Chickens that have been restricted fed early in the production and fed *ad libitum* at a later stage resulted in a compensatory growth (Bruggemen *et al.,* 1999). Apart from saving the quantity of feed given to chickens, feed restriction has been reported by several researchers in reducing mortality of chickens (Naraharl *et al.,* 1975; Lippens *et al.,* 2000 Tolkamp *et al.,* 2005 and Robert, 2009).

Season also plays an important role on the growth performance of chickens. Despite the fact that the Koekoek chicken has been developed to be adaptive under local conditions, this genetic potential cannot be achieved unless the extreme temperature problems have been adequately addressed. Exposure of chickens to extreme temperatures (low or high) during any phase of production has a negative impact on the body weight, body weight gain, FCR and mortality (Olanrewaju *et al.,* (2010). Increased temperatures experienced during the summer are capable of affecting negatively the body weight and weight gain of chickens, which is a net effect of reduced feed intake (Yalcin *et al.,* 1997a and Akyuz, 2009). On the other hand, low temperatures influence the performance of broiler chickens negatively because of the high feed intake, decreased body weight gain and feed efficiency (Blahova *et al.,* 2007). An improved feed conversion ratio (FCR) was found in birds that were kept in low temperatures as opposed to high temperatures (Veldkamp *et al.,* 2005 and Lu *et al.,* 2007). The extreme temperatures are a problem when chickens are kept in a house that cannot protect them from either hot or cold temperatures.

Although some work has been done on the effect of restricted feeding and season on chickens, still more studies are required to discover the appropriate rearing time and the feeding strategy management that can maximize genetic potential of Koekoek chickens without increasing the costs. As Koekoek chickens are classified under heavy dual purpose breeds (Nthimo, 2004), it is possible that they can benefit from restricted feeding the same way as broiler breeders. This study was aimed at investigating the effect of feeding level and season on the growth performance of Koekoek chickens.

2.2 Materials and Methods

2.2.1 Study site

This study was conducted at the experimental farm of the Faculty of Agriculture, National University of Lesotho (NUL) based in Roma.

2.2.2 Management of Birds

Two hundred and seventy (270) Koekoek hens and twenty-seven (27) Koekoek cocks at the age of eight weeks were bought from the Government Poultry National Hatchery in Maseru. The birds were from the same hatching batch and therefore they were of the same age. Prior to arrival at NUL, chickens were raised at the Poultry National Hatchery for seven weeks. They were raised on the deep litter system. They were given starter mash and water ad *libitum*. Sexing and new castle disease vaccine were done at the Hatchery. During the experiment, birds were raised on floor pens littered with dry grass (deep litter system). The floor space for each pen was 2.5m^2 and each pen accommodated 10 birds. The wall from the floor to the height of 1.5m was made of corrugated iron sheets. The wall height up to the roof was made of chicken wire mesh and the structure was roofed with corrugated iron sheets. The shelter was constructed in such a way to allow for good ventilation. Feeds were provided in suspended feeders and the cocks and hens shared the same feeders. Water was supplied in suspended drinkers *ad libitum*. Koekoek chickens were fed a pullet grower diet from the age of 8 to 18 weeks followed by laying mash feeding until the end of the research study (32 weeks). All Koekoek chickens were given a stress pack dissolved in water on arrival. Chickens that showed any sign of illness or diarrhoea were treated accordingly.

2.2.3 Experimental Design

The experiment was conducted using a completely randomized factorial design with feeding regime and season being factors as outlined by Steel and Torrie (1980).

Table 2.1: Experimental design of the research project

	Summer				Winter			
Pre- experimental phase (1-7 weeks)	Full-fed				Full-fed			
Rearing phase (8-18 weeks	**A**A Full-fed	**A**R Full-fed	**R**A Restricted	**R**R Restricted	**A**A Full-fed	**A**R Full-fed	**R**A Restricted	**R**R Restricted
Laying phase (19-32 weeks)	A**A** Full-fed	A**R** Restricted	R**A** Full-fed	R**R** Restricted	A**A** Full-fed	A**R** Restricted	R**A** Full-fed	R**R** Restricted

2.2.4 Treatment allocation

Two experiments were conducted to evaluate the effect of feeding level on the production and reproductive performance of Koekoek chickens under small scale farming conditions. The first experiment started from September 2008 to February 2009 while the second experiment was from March to August 2009 in order also to quantify seasonal effects. Each experiment had the same number of birds being 270 hens and twenty-seven (27) cocks.

Table 2.2: Temperature (^{o}C) conditions at Roma location from September 2008 to August 2009

Month	Minimum temperature (^{o}C)	Maximum temperature (^{o}C)
September	12	16
October	16	18.5
November	16.5	22
December	15	25
January	15	24.5
February	14.5	25
March	11.5	18
April	10	17
May	4	12
June	-1	7.5
July	0	6
August	3	13

Footnote:

Data on temperature is supplied by the Department of Geography of the National University of Lesotho weather station.

Two hundred and seventy (270) hens and twenty seven (27) cocks of age eight weeks were divided into four feeding regimes (levels) denoted as groups AA, AR, RA and RR with each treatment replicated seven times with the exception of birds in RR treatment which were replicated six times making a total of 27 experimental units. Each feeding regime treatment served 70 hens and 7 cocks in AA, AR and RA while the RR treatment had 60 hens and 6 cocks. Ten hens and one cock were kept in a pen. Chickens in group AA treatment were full-fed during the rearing and the laying phase. Birds in the AR treatment were full-fed during the rearing phase and were shifted to restricted feeding during the laying phase. Chickens in the group RA feeding regimen were on restricted feeding in the rearing phase and placed on full feeding during the laying period while in the last group (RR) the birds were subjected to feed restriction during both rearing and laying phases.

The restricted feeding was 70 percent of the total daily feed intake of the bird per day during both growing and laying periods. The feeding programme for chickens under restricted feeding during the rearing phase is shown on Table 2.2.

Table 2.3: The feeding program of Koekoek chickens under restricted feeding

Age of birds (weeks)	Daily feed intake/bird (grams)	70 percent of daily feed intake/bird (restricted feeding)
8	50	35
9	53	37
10	60	42
11	62	43
12	65	46
13	68	48
14	70	49
15	70	49
16	73	51
17	75	53
18	93	65

The average daily feed intake (Table 2.2) was based on records from the National Hatchery Poultry plant of the Ministry of Agriculture in Lesotho. This was also confirmed by the on-farm pilot study done at Roma Valley. Three farms were used in this pilot study in order to establish the Koekoek chickens feed intake. Ten chickens were given to each farmer. During the laying period, birds on restricted feeding were fed 84 grams of laying mash that is about 70 percent of their average daily feed intake (120g).

The feed used was a complete rearing and laying chicken diet bought from the commercial feed manufacturer (M) of which grower mash and layer mash composition was constituted as follows:

Table 2.4: Nutrient composition of grower mash and layer mash that was fed Koekoek chickens.

Nutrient	Grower mash (g/kg)	Layer mash(g/kg)
Crude protein	150.0	130.0
Moisture	120.0	120.0
Fibre (maximum)	65	70.0
Calcium (minimum)	27	27.0
Calcium (Maximum)	45.0	45.0
Phosphorus (minimum)	5.0	5.0
Lysine (minimum)	5.0	5.0

The chemical composition of the feed was confirmed by means of proximate analysis at the Nutrition Laboratory of the University of Pretoria.

Table 2.5: Analyzed nutrient composition of grower mash and layer mash

Nutrient	Grower mash	Layer mash
Crude protein (g/kg)	170.2	110.9
Moisture (g/kg)	100.0	95.0
Fat (g/kg)	22	24
Phosphorus (g/kg)	4.5	5.0

2.2.5 Data Collection

Throughout the experimental period Koekoek chickens (hens) were weighed on a weekly basis by choosing a random sample of 21 birds in the AA, AR, RA treatments and 18 birds in the RR treatment in order to establish their average weight for age, weight gains, feed intake and feed conversion ratio (FCR) with effect from the 10th week. The first two weeks were not included with the understanding of allowing adaptation period of chickens to the treatments. Feeding was done on daily basis at 7:00 am. The remaining feed was measured every day at 6:30 pm. The feed intake was taken as the difference between the total feed given to chickens in the morning and the remaining feed in the evening. The chickens FCR was calculated by dividing the total feed intake for every two weeks by the weight gain during a period of two weeks. All mortality was recorded.

2.2.6 Experimental Model

$$\mathbf{Y_{ij} = \mu + F_i + S_j + (F*S)_{ij} + E_{ij}}$$

Where:

$\mathbf{Y_{ij}}$ = Observation for Koekoek growth performance parameters

$\boldsymbol{\mu}$ = Overall mean

$\mathbf{F_i}$ = Effect of feed

$\mathbf{S_j}$ = Effect of season

$\mathbf{(F * S)_{ij}}$ = Interaction between the ith feed and jth season

$\mathbf{E_{ij}}$ = Error component

The arrival weights at 8 weeks were used as covariates in the model in order to correct the weekly weights of chickens up to 32 weeks.

2.2.7 Data analysis

Data was recorded in excel spreadsheet and averages were calculated. Data was tested for normal distribution. The analyses were done on transformed data. Multifactorial ANOVA was used to separate the effects of feeding level and season on body weights, body weight gain, feed intake, feed conversion ratio and mortality. If significant, treatment effects were analysed and differences between treatments were tested by Duncan's new multiple-range test (Duncan, 1955). The General Linear Models Procedure; SPSS (17.00) was used. Threshold for significance was $p < 0.05$.

2.3 Results and Discussion

The results of the growth performance of Koekoek chickens are presented in Table 2.6 and Figure 2.1. The results obtained from Table 2.6 indicate that during the rearing phase, birds that were full-fed (AA and AR) had higher ($p<0.05$) body weights than restricted fed groups (RA and RR). A critical analysis of the results from the 10th to the 18th week indicates that the difference between the mean weights of birds that were full-fed and the restricted fed group increases with the birds' age. This can be proved by the fact that the mean difference between birds that were on restricted feeding and full feeding increased by 22.2% from the age of 10 to 18 weeks (Figure 2.1). Full feeding increased the weight of the chickens by approximately 390g at the age of 18 weeks.

Table 2.6: Effects of restricted feeding on weight (g) for age of Koekoek chickens

	Treatment				
Age (wks)	**AA**	**AR**	**RA**	**RR**	**S.E**
Rearing phase (10 - 18 weeks)					
(Weights, g)					
10	774.6[a]	775.1[a]	729.7[b]	735.7[b]	1.36
11	888.8[a]	891.7[a]	809.4[b]	808.1[b]	3.47
12	1005.0[a]	1004.0[a]	829.7[b]	900.9[b]	2.68
13	1137.0[a]	1140.0[a]	957.6[b]	970.9[b]	2.80
14	1182.0a	1168.0[a]	991.3[b]	996.3[b]	2.62
15	1329.0[a]	1320.0[a]	1109.0[b]	1098.0[b]	5.95
16	1399.0[a]	1395.0[a]	1090.0[b]	1099.0[b]	3.40
17	1506.0[a]	1503.0[a]	1209.0[b]	1206.0[b]	7.33
18	1575.0[a]	1582.0[a]	1187.0[b]	1195.0[b]	3.95
Laying phase (19 - 32 weeks)					
(Weights, g)					
19	1690.0[a]	1648.0[b]	1435.0[b]	1389.0[b]	5.10
20	1786.0[a]	1690.0[b]	1522.0[c]	1394.0[d]	4.39
21	1831.0[a]	1638.0[b]	1693.0[c]	1539.0[d]	5.14
22	1933.0[a]	1751.0[b]	1768.0[c]	1544.0[d]	4.73
23	2020.0[a]	1667.0[b]	1950.0[c]	1677.0[d]	5.47
24	2095.0[a]	1818.0[b]	2033.0[c]	1678.0[d]	4.69
25	2185.0[a]	1735.0[b]	2153.0[a]	1801.0[b]	5.96
26	2243.0[a]	1867.0[b]	2253.0[a]	1780.0[b]	4.76
27	2227.0[a]	1814.0[b]	2235.0[a]	1871.0[b]	6.40
28	2323.0[a]	1852.0[b]	2426.0[a]	1853.0[b]	4.75
29	2212.0[a]	1808.0[b]	2201.0[a]	1858.0[b]	7.29
30	2369.0[a]	1808.0[b]	2498.0[c]	1875.0[d]	5.21
31	2379.0[a]	1819.0[b]	2526.0[c]	1887.0[d]	6.04
32	2411.0[a]	1812.0[b]	2561.0[c]	1891.0[d]	5.00

[Abcd] Means within a row with no common superscript differ significantly (p<0.05).

Footnote:

AA-Full feeding during rearing and laying. AR-full feeding during rearing and restricted during laying, RA-restricted feeding during rearing and full feeding during laying, RR-restricted during rearing and laying, S.E-standard error.

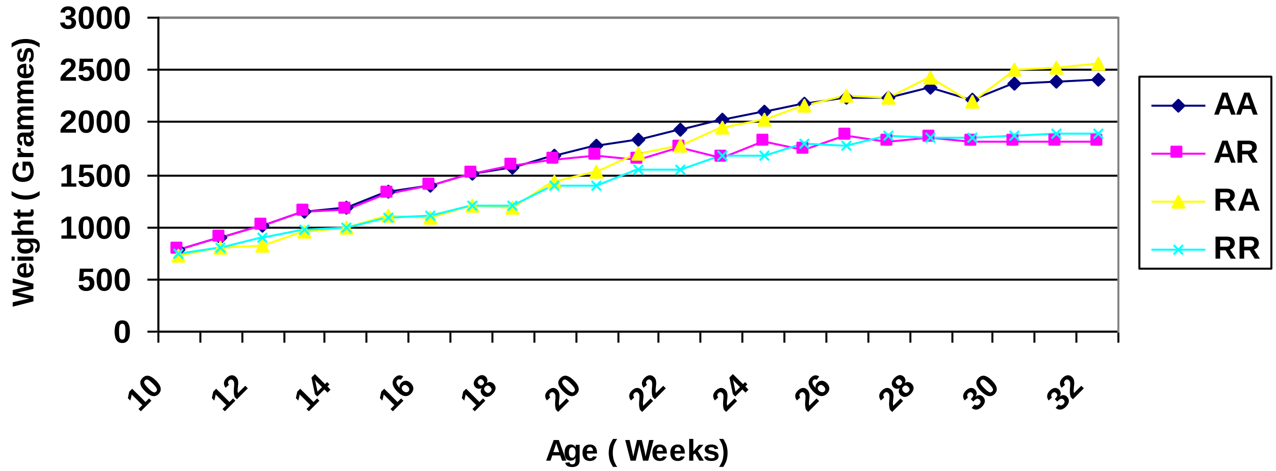

Figure 2.1: Growth curve of Koekoek chickens raised under different feeding levels

AA-Full feeding during rearing and laying. AR-full feeding during rearing and restricted during laying, RA-restricted feeding during rearing and full feeding during laying, RR-restricted during rearing and laying,

In the laying phase, birds that were full-fed during both phases (AA) continued to grow faster ($p<0.05$) than those in all other treatments (AR, RA and RR) up until birds reached 24 weeks of age. Koekoek chickens that were transferred from restricted to full feeding in the laying phase (RA) were seen to grow out birds that were under restricted feeding treatments (AR and RR) in the laying phase and this was seen to be effective from the 21st week of age. This means that it took almost 14 days for birds under RA treatment to adjust and respond to unrestricted feeding. Koekoek chickens that were under RA treatment seemed to accelerate their growth rate from the 21st week up to the end of the experimental trial, which was 32 weeks of age. Due to the compensatory growth, birds in the RA treatment were 133 to 155g heavier than birds that were under AA treatment for the last three weeks of the experimental period. At 25 weeks of age the results indicate no significant ($p>0.05$) differences between Koekoek chickens that were in the AR and RR treatments. The same trend was observed between the two restricted fed treatments during the laying phase until Koekoek chickens reached an age of 29 weeks. The body weights in the RR and AR treatments were increased by approximately 16g and 4g respectively during the last three weeks of the study. This could also be because birds that were feed restricted throughout the experiment (RR) were adapted to the situation as compared to birds that were restricted only in the laying phase (AR).

The results obtained from this research project are in agreement with the results of Tesfaye *et al*. (2009) who indicated that the growth of hens is reduced by feed restriction. Mahmood *et al*. (2007) also said that feed restriction reduced adult body weight of chickens by 20% compared with *ad libitum* fed chickens. Mahmood *et al.* (2007) and Tasfaye *et al.* (2009) also reported a reduced weight gain in feed restricted birds. The explanation of the lower body weight in feed restricted birds could probably be attached to the lower amount of feed intake compared to full-fed birds. The results obtained from this study agree with the findings of Fontana *et al*. (1992); Lippens *et al*. (2000); Mahmood (2007); Khetani *et al*. (2008) and Sogut and Kalpak (2009) who reported lower feed intake in feed restriction than *ad libitum* in the feeding programme. In a study that was conducted in quails, Hassan *et al*. (2003) found the similar results. They continued to enphasize that birds will later exhibit an accelerated body weight gain when allowed access to unrestricted feeds. Mahmood *et al*. (2007) also indicated that birds with retarded growth due to poor nutrition could achieve a growth rate higher than normal for chronological age after removal of the feed restriction. The previous findings explained that compensatory growth or catch up growth exhibited by restricted fed birds allows the recovery of body weight at slaughter age and sometimes a higher body weight than that of birds fed *ad libitum* as was the case with this research project. The results of this research study showed that RR treatment reduced the average body weights by 400, 310 and 130g than AA, AR and RA treatments respectively at the age 20 weeks ($p<0.05$). In a study that was conducted on quails, Hassan *et al*. (2003) indicated that the body weight at first egg is significantly less in restricted fed groups compared to the ad *libitum* fed groups.

Koekoek chickens that were reared in summer had higher ($p<0.05$) weights from the start of the experiment until the end of the rearing period (18 weeks) as shown in Table 3.6. The results revealed a difference of 178.7g between the birds that were kept in summer and in winter at the age of 10 weeks. The similar trend of the results was observed up until birds were 18 weeks being the expected age for puberty in Koekoek chickens. At 18 weeks of age, the mean body weight of Koekoek chickens that were kept in summer was 25% higher than in winter.

During this second phase of growing in Koekoek chickens the results clearly showed that Koekoek chickens raised in summer had higher ($p<0.05$) body weights compared to those reared in winter.

Table 2.7: Weight (g) for age of Koekoek chickens reared in either summer or winter during both rearing and laying phases

	Seasons		
Age (wks)	**Summer**	**Winter**	**S.E**
Rearing phase (10 - 18 weeks)			
(Weights, g)			
10	843.1[a]	664.4[b]	5.76
11	1003.0[a]	695.8[b]	6.99
12	1121.0[a]	780.1[b]	6.07
13	1170.0[a]	933.1[b]	5.59
14	1230.0[a]	938.6[b]	5.82
15	1333.0[a]	1095.0[b]	11.87
16	1402.0[a]	1088.0[b]	7.43
17	1442.0[a]	1270.0[b]	14.60
18	1547.0[a]	1223.0[b]	7.30
Laying phase (19 - 32 weeks)			
19	1722.0[a]	1359.0[b]	10.21
20	1725.0[a]	1471.0[b]	9.03
21	1780.0[a]	1571.0[b]	10.33
22	1881.0[a]	1617.0[b]	8.92
23	1998.0[a]	1659.0[b]	10.84
24	2071.0[a]	1740.0[b]	8.94
25	2137.0[a]	1800.0[b]	12.23
26	2220.0[a]	1851.0[b]	9.10
27	2165.0[a]	1908.0[b]	2.91
28	2312.0[a]	1916.0[b]	9.98
29	2096.0[a]	1942.0[b]	14.93
30	2344.0[a]	1931.0[b]	10.77
31	2384.0[a]	1922.0[b]	12.48
32	2373.0[a]	1965.0[b]	10.40

[ab] Means within a row with no common superscript differ significantly ($p<0.05$).

The results as indicated in Table 2.7 reflect the effect of interaction between the feeding level and season. The body weights of Koekoek chickens that were in the AA, AR, RA and RR treatments in summer were 195, 194, 160 and 166g higher than their counterparts in winter at the age of 10 weeks. This shows that birds on the AA and AR performed much better in summer compared to winter. On the RA and RR feeding regimes, birds raised in summer were still heavier than those raised in winter though the differences were not comparable with the other two feeding regimes. At 18 weeks of age the body weights of chickens that were under the AA, AR, RA and RR treatments during the summer were higher than the ones in winter by 21.8%, 21.6%, 20.2% and 19.6% respectively. The final body weights of chickens raised in summer were heavier than the ones in winter despite the level of feeding. The differences between weights of chickens during the summer and winter on the AA, AR, RA and RR treatments were 496, 226, 641 and 270g respectively. This means that birds in the RA followed by the ones in the AA treatment in summer performed much better than those in winter. Similarly, birds on the AR and RR treatment in summer still performed out their counterparts in winter though the differences were lower compared to those that were full-fed during the laying phase.

It was difficult to compare this study with previous ones because of the different environmental temperatures involved. The previous researchers (Bonnet *et al.*, 1997; Plavnik and Yahav, 1998; Yalcin *et al.*, 1997a; Deeb and Cahaner, 1999; Reem and Cahaner, 1999; 2001 and Aksit *et al.*, 2006) regarded high temperatures to be above 32^0C while in this case the summer temperatures ranged from 17 to 24^0C. The winter temperatures in Lesotho can go below 0^oC, whilst the previous researchers were considering 21^0C as a cooler season (Lu *et al.*, 2007). It is therefore believed that the low temperatures in winter had negatively affected the growth of Koekoek chickens because birds utilized some energy from the feeds to generate heat. Summer temperatures in Lesotho did not have a negative effect on the eating pattern of the Koekoek chickens. This could be true because Koekoek chickens were fed in the morning (7.00 am) while the temperatures were still low. However, in a study that compared the performance of birds under different environmental temperatures, Lu *et al.* (2007) reported insignificant differences with respect to final body weights between the local Beijing You chickens. Lu *et al.* (2007) also pointed out that the commercial Arbor Acres chickens that were subjected to high temperatures performed significantly lower than those that were kept at a low temperature. Some studies also concluded that the higher temperatures adversely affect the body weights of commercial chickens (Bonnet *et al.,* 1997; Plavnik and Yahav, 1998; Yalcin *et al.,* 1997a; Deeb and Cahaner, 1999a; 1999b; Reem and Cahaner, 1999; 2001 and Aksit *et al.,* 2006). In a study done in turkeys Veldcamp *et al*. (2005) also indicated that the body weight of turkeys that were exposed to a higher temperature were 19.7% lower than those that were kept at a lower temperature.

Table 2.8: Effect of the interaction between feeding level and season on weight (g) for age of Koekoek chickens

	Treatment*season															
Age (wks)	**SAA**	**S.E**	**WAA**	**S.E**	**SAR**	**S.E**	**WAR**	**S.E**	**SRA**	**S.E**	**WRA**	**S.E**	**SRR**	**S.E**	**WRR**	**S.E**
10	872.1^{a}	6.67	677.1^{b}	7.84	872.1^{a}	8.23	678.1^{b}	7.47	809.4^{a}	7.34	649.9^{b}	8.24	818.8^{a}	7.34	652.6^{b}	8.18
11	1058.0^{a}	22.14	719.5^{b}	20.02	1071.0^{a}	20.99	712.5^{b}	19.07	942.3^{a}	18.75	676.6^{b}	21.41	941.6^{a}	18.95	674.6^{b}	20.87
12	1209.0^{a}	17.18	801.5^{b}	15.45	1202.0^{a}	16.19	805.6^{b}	14.17	1032.0^{a}	14.47	753.9^{b}	16.23	1043.0^{a}	14.62	759.2^{b}	16.11
13	1267.0^{a}	17.82	1006.0^{b}	16.12	1279.0^{a}	16.90	1001.0^{b}	15.36	1055.0^{a}	15.10	860.0^{b}	16.94	1077.0^{a}	15.26	865.1^{b}	16.82
14	1348.0^{a}	16.68	1015.0^{b}	15.08	1330.0^{a}	15.81	1006.0^{b}	14.37	1119.0^{a}	14.13	863.9	15.85	1123.0^{a}	14.28	869.9^{b}	15.73
15	1483.0^{a}	37.92	1175.0^{b}	34.30	1458.0^{a}	35.95	1182.0^{b}	32.67	1207.0^{a}	32.12	1012.0^{b}	36.04	1184.0^{a}	32.47	1011.0^{b}	35.78
16	1577.0^{a}	21.63	1220.0^{b}	19.57	1571.0^{a}	20.50	1218.0^{b}	18.64	1228.0^{a}	18.35	951.7^{b}	20.56	1233.0^{a}	18.52	963.9^{b}	20.41
17	1591.0	4667	1421.0	42.22	1593.0	44.25	1412.0	40.21	1300.0	39.54	1118.0	44.36	1283.0	39.96	1128.0	44.07
18	1768.0^{a}	25.18	1382.0^{b}	22.78	1774.0^{a}	23.88	1391.0^{b}	21.70	1320.0^{a}	21.34	1053.0^{b}	23.94	1325.0^{a}	21.56	1065.0^{b}	23.76
19	1863.0^{a}	32.47	1517.0^{b}	29.38	1784.0^{a}	30.79	1512.0^{b}	27.98	1659.0a	27.51	1210.0^{b}	30.87	1579.0^{a}	27.81	1198.0^{b}	30.64
20	1948.0^{a}	27.93	1624.0^{b}	25.26	1875.0^{a}	26.48	1506.0^{b}	24.06	1603.0^{a}	23.66	1440.0^{b}	26.54	1475.0^{a}	23.91	1313.0^{b}	26.35
21	1950.0^{a}	32.76	1711.0^{b}	29.64	1638.0^{a}	31.06	1638.0^{b}	28.23	1846.0^{a}	27.76	1541.0^{b}	31.14	1684.0^{a}	28.05	1394.0^{b}	30.91
22	2108.0^{a}	30.13	1758.0^{b}	27.25	1898.0^{a}	28.56	1604.0^{b}	25.96	1900.0^{a}	25.52	1636.0^{b}	28.64	1618.0^{a}	25.80	1470.0^{b}	28.43
23	2250.0^{a}	34.87	1790.0^{b}	31.55	1664.0^{a}	33.06	1670.0^{b}	30.05	2207.0^{a}	29.54	1693.0^{b}	33.15	1872.0^{a}	29.86	1482.0^{b}	32.91
24	2295.0^{a}	29.89	1895.0^{b}	27.04	1977.0^{a}	28.34	1658.0^{b}	25.75	2243.0^{a}	25.32	1822.0^{b}	28.41	1771.0^{a}	25.59	186.0^{b}	28.20
25	2422.0^{a}	37.96	1948.0^{b}	34.34	1732.0^{a}	35.99	1739.0^{b}	32.70	2406.0^{a}	32.16	1899.0^{b}	36.08	1989.0^{a}	32.50	1613.0^{b}	35.82
26	2448.0a	30.32	2037.0^{b}	27.45	2034.0^{a}	28.74	1701.0^{b}	26.12	2501.0^{a}	25.68	2005.0^{b}	28.82	1897.0^{a}	25.96	1663.0^{b}	28.61
27	2375.0^{a}	40.80	2080.0^{b}	36.91	1872.0^{a}	38.68	1755.0^{b}	35.15	2379.0^{a}	34.56	2090.0^{b}	38.78	2035.0^{a}	34.93	1707.0^{b}	38.49
28	2546.0^{a}	30.25	2101.0^{b}	27.36	2008.0^{a}	28.68	1697.0^{b}	26.06	2702.0^{a}	25.62	2151.0^{b}	28.75	1990.0^{a}	25.90	1715.0^{b}	28.54
29	2290.0^{a}	46.44	2134.0^{b}	42.02	1896.0^{a}	44.04	1718.0^{b}	40.02	2220.0^{a}	39.35	2182.0^{b}	44.15	1979.0^{a}	39.77	1736.0^{b}	43.83
30	2608.0^{a}	33.17	2131.0^{b}	30.01	1953.0^{a}	31.45	1663.0^{b}	28.58	2803.0^{a}	28.10	2193.0^{b}	31.53	2012.0^{a}	28.40	1738.0^{b}	31.30
31	2653.0^{a}	38.43	2105.0^{b}	34.79	1969.0^{a}	36.47	1669.0^{b}	33.14	2867.0^{a}	32.59	2850.0^{b}	36.56	2045.0^{a}	32.94	1729.0^{b}	36.30
32	2659.0^{a}	31.82	2163.0^{b}	28.78	1925.0^{a}	30.17	1699.0^{b}	27.41	2882.0^{a}	26.96	2241.0^{b}	30.24	2026.0^{a}	27.25	1756.0^{b}	30.02

^{ab} Means within a row with no common superscript differ significantly ($p<0.05$).

Footnote:

SAA-full feeding during rearing and laying in summer season. SAR-full feeding during rearing and restricted during laying in summer season, SRA-restricted feeding during rearing and full feeding during laying in summer season, SRR-restricted during rearing and laying in summer season, WAA-full feeding during rearing and laying in winter season. WAR-full feeding during rearing and restricted during laying in winter season, WRA-restricted feeding during rearing and full-feeding during laying in winter season, WRR-restricted during rearing and laying in winter season, S.E-standard error

Table 2.9: Body weight gain (g) of Koekoek chickens subjected to different feeding level treatments

	Treatment				
Age (wks)	**AA**	**AR**	**RA**	**RR**	**S.E**
Rearing phase (10 - 18 weeks)					
(Weights, g)					
10	117.1[a]	117.6[a]	72.2[b]	78.2[b]	1.36
12	230.4[a]	228.7[a]	163.0[b]	165.2[b]	2.97
14	176.6[a]	163.9[a]	98.6[b]	95.34[b]	2.35
16	217.3[a]	227.0[a]	98.4[b]	102.3[b]	2.57
18	176.3[a]	187.8[a]	97.2[b]	96.3[b]	2.62
8-18	917.8[a]	924.9[a]	529.4[b]	537.4[b]	3.95
Laying phase (20 - 32 weeks)					
(Weights, g)					
20	211.1[a]	107.8[b]	334.9[c]	199.4[d]	3.10
22	146.7[a]	60.4[b]	246.3[c]	149.5[a]	2.71
24	161.8[a]	67.0[b]	264.4[c]	134.7[d]	2.22
26	147.9[a]	49.8[b]	220.5[c]	101.8[d]	3.25
28	80.8[a]	-14.9[b]	173.4[c]	72.3[a]	2.75
30	45.8[a]	-44.6[b]	71.5[c]	22.1[d]	1.96
32	42.3[a]	4.6[b]	63.0[c]	16.0[d]	4.99
19-32	721.7[a]	164.6[b]	1126.0[c]	501.9[d]	6.54
8-32	1754.0[a]	1155.0[b]	1904.0[c]	1234.0[d]	4.99

[abcd] Means within a row with no common superscript differ significantly ($p<0.05$).

Footnote:

AA-full feeding during rearing and laying. AR-full feeding during rearing and restricted during laying, RA-restricted feeding during rearing and full feeding during laying, RR-restricted during rearing and laying, S.E-standard error.

Results in Table 2.9 show that Koekoek chickens that were full-fed during the rearing phase had higher body weight gains ($p<0.05$) compared to those that were feed restricted. Koekoek chickens that were in the AA and AR treatments gained 41.9g more weight than those in the RA and RR treatments at 10 weeks of age. When looking at the cumulative body weight gain for the period covering 10 to 18 weeks, birds in the full-fed group gained significantly more weight than the feed restricted group with an average weight difference of 42.1%. These results suggest that both feeding level groups of Koekoek chickens demonstrated a continuous growth from the 10th week up to the 18th week, which is the expected age for first oviposition. The results from this study displayed a positive correlation of $r=0.76$ between the total feed intake and the weight gain during the rearing period. This reveals that the more feed the chickens are consuming the faster they will gain weight.

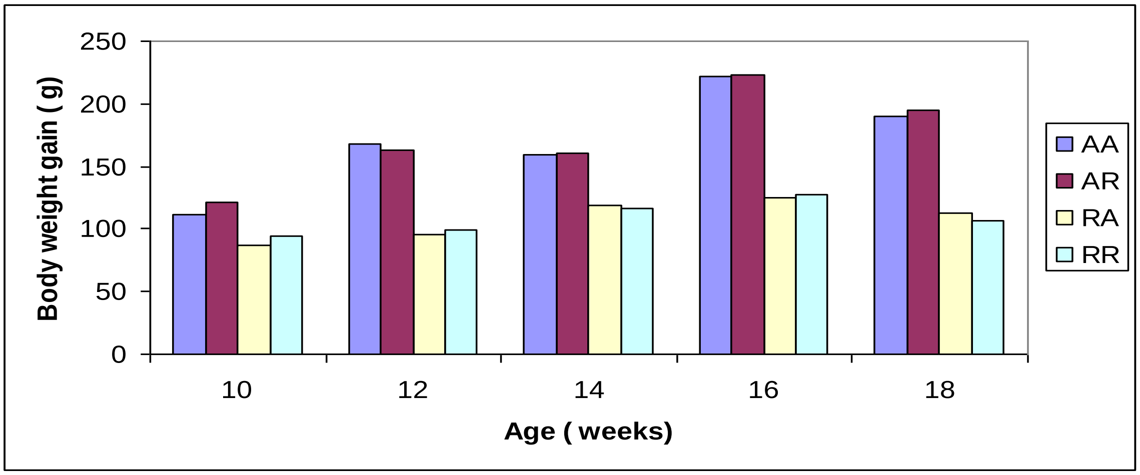

Figure 2.2: Body weight gain of Koekoek chickens subjected to different feeding levels from 10 to 18 weeks

Footnote:

AA-full feeding during rearing and laying. AR-full feeding during rearing and restricted during laying, RA-restricted feeding during rearing and full feeding during laying, RR-restricted during rearing and laying,.

During the laying phase, Koekoek chickens that were subjected to early feed restriction and shifted to unrestricted feeding in the laying phase (RA) gained 34%, 67.8% and 40.5% more ($p<0.05$) weight than those in the AA, AR and RR treatments respectively. Chickens in the AA, RA and RR treatments gained weight throughout the trial period as against those in the AR treatment, which lost body weight effectively from the age of 28 weeks up to the 30th week of the experiment. When considering cumulative body weight gain between the four treatments it can be noticed that the weight gain diferences between birds in the RA treatment and those in the AA, AR and RR treatments were 404.3, 961.4 and 624.1g respectively. The results of this study showed a similar pattern even on the grand commutative weight gains (8 to 32 weeks) with the birds in the AR treatment gaining 599, 749 and 79g less compared to those in the AA, RA and RR treatments respectively. The weight gain was 6.8% among the restricted fed (AR and RR) and 20% between the full-fed ones. A higher weight gain difference was noticed between the full-fed and restricted fed chickens in the laying phase. A positive correlation ($r=0.59$) was experienced between the total feed intake and the grand body weight gain of chickens.

The findings of this study are in agreement with the results of Mahmood *et al.* (2007) who found that a reduced weight gain in restricted fed birds is the result of a reduced feed intake compared to *ad libitum* fed birds. The results of Eitan and Soller (2001) also indicated that the body weight of restricted fed birds was significantly less at first egg compared to those in the control group. Birds that were under restricted feeding reached sexual maturity at a lower body weight than those under *ad libitum* feeding. This is in line with Colin *et al*. (1992) who suggested that feed restriction should be practiced on heavy breeds in order to avoid the excessive amount of body fat in pullets at sexual maturity and that feed restriction would result in targeted body size before birds start to lay.

Eitan and Soller (2001) indicated a gain in body weight of chickens that were feed restricted earlier and later shifted to *ad libitum* feeding. This is in line with the findings of the present study that revealed that Koekoek chickens that were in the RA treatment had better mean body weight gains. This can further be argued in terms of the compensatory growth principle. Birds in the AR treatment lost body weight from the age of 28 weeks and this could be because the limited feeds they were getting were not satisfying their growing demands since it is assumed that chickens would require more feed as they age. The same argument could justifiably be correct as the daily feed requirement for the layers is between 104 to 118g per bird in a complete diet (Douglas and Quart, 1992). Tolkamp *et al*. (2005) indicated that restricted fed birds normally loose weight during the peak laying period because the nutrients intake of birds fails to meet their metabolic requirement, which is believed to be the case in this study.

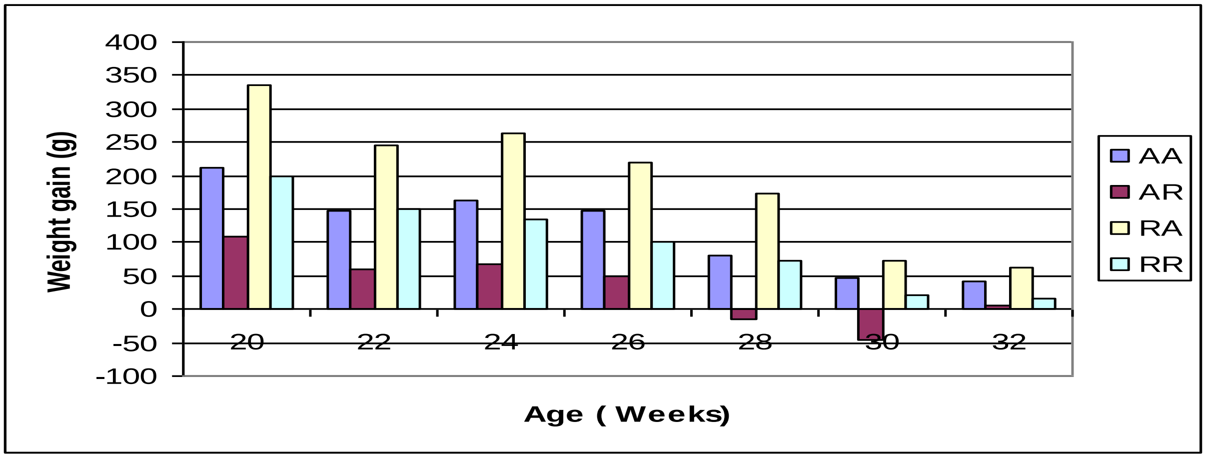

Figure 2.3: Body weight gain of Koekoek chickens subjected to different feeding levels from 20 to 32 weeks
Footnote:
AA-full feeding during rearing and laying. AR-full feeding during rearing and restricted during laying, RA-restricted feeding during rearing and full feeding during laying, RR-restricted during rearing and laying, S.E-standard error.

The results for the influence of season on the weight gain of Koekoek chickens are demonstrated on Table 3.9. These results show that season had an effect on the weight gain of Koekoek chickens. Koekoek chickens gained more ($p<0.05$) body weight in summer than in winter. At the age of 10 weeks, the weight gain difference was 116.3g between chickens that were kept in summer and winter. At puberty (18 weeks) the mean weight gain for Koekoek chickens that were kept in summer was 7% less ($p<0.05$) than in winter.

The differences in the weight gains of birds can be attributed to the seasonal temperature effect. Koekoek chickens that were raised in summer were performing better ($p<0.05$) than those in winter for the first four weeks of the experiment (week 10 to week 14). The assumption for the significant differences at the beginning of the study could be attributed to the fact that at young age the chickens were more exposed to coldness because of less feather coverage hence the other feed portion was used for body heat generation instead of body weight gain.

Table 2.10: Body weight gain (g/d) of Koekoek chickens that were reared either in summer or winter during both rearing and laying phases

	Season		
Age (wks)	**Summer**	**Winter**	**S.E**
Rearing phase (10 - 18 weeks)			
(Weights, g)			
10	185.6[a]	69.3[b]	7.07
12	278.0[a]	115.6[b]	5.69
14	158.5[a]	108.7[b]	2.60
16	172.6	149.9	3.06
18	144.4	134.3	3.04
Overall (10-18)	889.4[a]	565.3[b]	0.05
Laying phase (20 - 32 weeks)			
(Weights, g)			
20	178.6[a]	148.1[b]	4.08
22	155.4	146.1	2.56
24	190.7[a]	123.3[b]	2.37
26	148.8	111.2	5.66
28	91.4	64.4	3.32
30	32.2	15.2	2.64
32	34.0	29.0	2.55
Overall (19-32)	651.5[a]	605.6[b]	13.07
Overall (10-32)	1716.0[a]	1308.0[b]	12.26

[ab] Means within a row with no common superscript differ significantly ($p<0.05$).

During the laying phase Koekoek chickens that were kept in summer registered more body weight gains compared to those kept in winter. At the beginning of the laying period (20 weeks) the weight gains for Koekoek chickens were reduced by 17.1% in winter ($p<0.05$). The overall weight gain in winter was 91.5% of the one in summer.

In support of the results of the present study, Akyuz (2009) showed that rearing birds in summer could result in higher body weight gains compared to birds kept in winter though the differences were not significant. In contradiction to the findings of this study, Yalcin *et al.* (1997b) stated that the body weight gain of chickens that are exposed to summer would be less by 23%. Deeb and Cahaner (2001a) also shared the same sentiments. The two studies explain that the reduced weight in summer was because birds had a low feed intake due to heat stress, which the same argument would not apply to the situation in Lesotho as the temperatures can hardly exceed 28^0C. The higher weight gain of Koekoek chickens in summer in this study can be explained by the fact that the majority of feeds consumed in summer contributed mainly to the growth of chickens while in winter the chickens would need some energy for warmth.

Filho *et al.* (2005) reported that higher temperatures normally stimulate hyperthermia and dehydration, which will lead to reduced feed intake and hence delayed growth. In a study done in turkeys Veldkamp *et al.* (2000) also shared the similar view that high temperature would result in significantly lower body weight gains of 22%. This inverse relationship between the environmental temperature and body weight gain of poultry was also reported by Mendes *et al.* (1997). On the other hand, the findings of this study partially confirm the experiment conducted by Blahova *et al.* (2007) who indicated that the effect of temperature on the body weight gain of chicken broilers was not significant. This can be proved by the fact that the insignificant weight gain scores were recorded most of the time except in week 20 and 24 where the significant values were observed between Koekoek chickens that were raised in two different seasons.

In the rearing phase, the results depicted the interaction between the feeding level and season during the first four weeks of the study (10-14 weeks of age). Koekoek chickens that were under the AA, AR, RA and RR in summer gained weight more ($p<0.05$) rapidly than in winter. In this period, the findings revealed that either restricted feeding or full feeding would produce better results in terms of weight gains as long as Koekoek chickens are reared in summer as illustrated in Table 3.9. This indicated that winter conditions hindered the weight gain of Koekoek chickens. The overall weight gain of Koekoek chickens clearly showed a significant interaction between the feeding level and the season. The results pointed that feeding Koekoek chickens unrestrictedly in summer (SAA and SAR) was more beneficial as chickens achieved more body weight as compared to birds that were subjected to other interactive combinations (WAA, WAR, SRA, WRA, SRR and WRR). The chickens that were fed restrictedly in winter (WRA and WRR) evidenced the least in terms of weight gain. This showed that feeding chickens restrictedly in winter possibly disadvantaged the chickens' potential to gain more weight.

During the laying phase (19-32weeks) an interaction ($p<0.05$) was only detected on the 24th and 32nd weeks of age in Koekoek chickens. At the 24th week the results showed that chickens that were in the AA, AR, RA and RR treatments in summer gained 27.2%, 30.8%, 45.9% and 23.7% more body weight (343.3g) than in winter. The weight gain difference was more prominent in the RA treatment. The findings of these results clearly demonstrate that all ages birds that were kept in summer gained more ($p<0.05$) weight than those that were kept in winter irrespective of the treatment. At week 32, the results specify that chickens that were in the RA treatment in summer still gained more (79.02g) weight as compared to chickens in other treatments. These results indicated that chickens that were in the SAR and WAR treatments lost weight from week 28 up to the 30th week with the weight loss extending to the 32nd week in the SAR chickens. This implies that the feed requirements of Koekoek chickens that were in those treatments during laying were higher than what was offered to them. This clearly states that at peak laying chickens will normally lose weight if they are underfed irrespective of the time of the year since it is assumed that some of the energy is used in the development of an egg.

The total weight gain differences between chickens under the AA, AR, RA and RR treatments in summer and winter were 496, 225, 641 and 111.4g respectively. Birds kept in summer performed better in all treatments except in the RR treatment. This means that chickens that were fed more in summer had improved weight gain as compared to feeding chickens restrictedly in winter. This entails that it would be better to restrict Koekoek chickens in summer rather than in winter. In a case where a maximum weight gain is aimed in winter, a farmer should be prepared to use more feed in winter even though the weight gain of Koekoek chickens would still not match the one in summer .

Table 2.11: Effect of the interaction between feeding level and season on weight gain (g/d) of Koekoek chickens

	Treatment* Season															
Age	**SAA**	**S.E**	**WAA**	**S.E**	**SAR**	**S.E**	**WAR**	**S.E**	**SRA**	**S.E**	**WRA**	**S.E**	**SRR**	**S.E**	**WRR**	**S.E**
10	214.6^{a}	8.67	19.6^{b}	7.84	214.6^{a}	8.22	20.6^{b}	7.4	151.9^{a}	7.34	-7.6^{b}	8.24	161.3^{a}	7.42	-4.9^{b}	8.27
12	336.4^{a}	18.92	124.4^{b}	17.12	329.9^{a}	17.94	127.5^{b}	16.3	222.1^{a}	16.03	104.0^{b}	17.98	223.8^{a}	16.20	106.6^{b}	17.85
14	139.8 ^{a}	15.00	213.4^{b}	13.57	127.7^{a}	14.22	200.0^{b}	12.9	87.1^{a}	12.71	110.1^{b}	14.26	80.0^{a}	12.84	110.7^{b}	14.15
16	229.0	16.40	205.6	14.84	241.8	15.55	212.1	14.1	109.0	13.89	87.8	15.59	190.7	16.70	94.0	15.48
18	190.7	16.70	161.9	15.12	202.6	15.83	172.9	14.4	92.6	14.15	101.7	15.87	91.71	14.30	100.8	15.76
10-18	1111^{a}	25.18	724.9^{b}	22.78	1117^{a}	23.88	733.2^{b}	21.7	662.8^{a}	21.34	396.0^{b}	23.94	667.6^{a}	21.56	407.2^{b}	23.76
20	180.2	19.72	241.9	17.84	100.8	18.70	114.9	17.0	282.9	16.71	386.9	18.75	150.3	16.89	248.6	18.61
22	159.4	17.27	134.0	15.62	22.6	16.37	98.1	14.9	296.9	14.63	195.8	16.42	142.6	14.79	156.4	16.30
24	187.3^{a}	14.15	136.3^{b}	12.80	79.2^{a}	13.42	54.8^{b}	12.2	343.3^{a}	11.99	185.6^{b}	13.45	152.8^{a}	12.12	116.6^{b}	13.36
26	153.1	20.69	142.6	18.72	57.3	19.62	42.2	17.8	257.9	17.53	183.1	19.67	126.8	17.72	76.9	19.53
28	97.9	17.55	63.7	15.87	-26.1	16.63	-3.8	15.1	201.1	14.86	145.8	16.68	92.8	15.02	51.7	16.55
30	61.9	12.46	29.7	11.27	-55.1	11.82	-34.2	10.7	79.0	10.56	47.7	11.85	14.2	10.67	18.9	11.76
32	51.3^{a}	11.82	32.8^{b}	10.74	-28.0^{a}	10.56	36.6^{b}	11.9	21.6^{a}	10.67	22.6^{b}	11.76	14.2^{a}	31.82	18.9^{b}	28.70
20-32	795.7	41.64	646.3	37.67	140.7	39.48	187.2	35.9	122.3	35.28	103.10	39.58	446.8	35.6	558.2	39.29
10-32	2002^{a}	31.82	1506^{b}	28.78	1267^{a}	30.17	1042^{b}	27.4	2224^{a}	26.96	1583^{b}	30.24	1369^{a}	27.25	1099^{b}	30.02

^{ab} Means within a row with no common superscript differ significantly (p<0.05 and p<0.01).

Footnote:

SAA-full feeding during rearing and laying in summer season. SAR-full feeding during rearing and restricted during laying in summer season, SRA-restricted feeding during rearing and full feeding during laying in summer season, SRR-restricted during rearing and laying in summer season, WAA-full feeding during rearing and laying in winter season. WAR-full feeding during rearing and restricted during laying in winter season, WRA-restricted feeding during rearing and full-feeding during laying in winter season, WRR-restricted during rearing and laying in winter season, S.E-standard error

Table 2.12: Feed intake per day (g/d) of Koekoek chickens that were subjected to different levels of feeding

			Treatment		
Age (wks)	**AA**	**AR**	**RA**	**RR**	**S.E**
Rearing phase (10 - 18 weeks)					
(Weights, g)					
10	54.2^{a}	54.4^{a}	42.8^{b}	42.0^{b}	0.143
11	59.8^{a}	59.8^{a}	43.0^{b}	43.0^{b}	0.003
12	63.5^{a}	63.5^{a}	46.0^{b}	46.0^{b}	0.007
13	66.6^{a}	66.5^{a}	48.0^{b}	48.0^{b}	0.007
14	70.8^{a}	70.9^{a}	49.0^{b}	49.0^{b}	0.011
15	80.0^{a}	80.0^{a}	56.0^{b}	56.0^{b}	0.002
16	79.6^{a}	79.6^{a}	56.0^{b}	56.0^{b}	0.043
17	81.4^{a}	81.2^{a}	57.0^{b}	57.0^{b}	0.074
18	83.0^{a}	83.0^{a}	58.0^{b}	58.0^{b}	0.010
8-18	494^{a}	494^{a}	359^{b}	3585^{b}	1.500
Laying phase (19 - 32 weeks)					
(Weights, g)					
19	100.7^{a}	85.0^{b}	88.9^{c}	73.4^{d}	0.135
20	115.0^{a}	83.7^{b}	117.0^{c}	83.9^{b}	0.089
21	117.0^{a}	84.0^{b}	117.2^{a}	84.0^{b}	0.020
22	116.5^{a}	83.9^{b}	116.9^{a}	84.0^{b}	0.056
23	117.2^{a}	84.0^{b}	117.2^{a}	84.0^{b}	0.028
24	117.2^{a}	84.0^{b}	117.2^{a}	84.0^{b}	0.008
25	117.3^{a}	84.0^{b}	117.3^{a}	84.0^{b}	0.015
26	117.4^{a}	84.0^{b}	117.4^{a}	84.0^{b}	0.002
27	117.3^{a}	84.0^{b}	117.3^{a}	84.0^{b}	0.012
28	117.1^{a}	84.1^{b}	117.3^{a}	84.0^{b}	0.018
29	117.1^{a}	84.0^{b}	117.3^{a}	84.0^{b}	0.013
30	117.2^{a}	84.0^{b}	117.4^{a}	84.0^{b}	0.009
31	117.4^{a}	84.0^{b}	117.0^{a}	84.0^{b}	0.003
32	117.4^{a}	84.0^{b}	117.4^{a}	84.0^{b}	0.002
19-32	10530^{a}	7649^{b}	10470^{c}	7569^{d}	1.178
10-32	15480^{a}	12600^{b}	14060^{c}	11150^{d}	1.825

^{abcd} Means within a row with no common superscript differ significantly (p<0.05).

Footnote:

AA-full feeding during rearing and laying. AR-full feeding during rearing and restricted during laying, RA-restricted feeding during rearing and full feeding during laying, RR-restricted during rearing and laying, S.E-standard error.

Koekoek chickens that were not limited on feeding had higher (p<0.05) feed intakes compared to those that were feed restricted for the entire rearing period (Table 2.12). Koekoek chickens that were fed restrictedly were consuming all their feeds that is 70% of the feed supplied to full-fed chickens. At the beginning of the trial, the average feed intake for unrestricted fed Koekoek chickens was 21.9% higher than in the restricted fed chickens. During the final week of the rearing phase, the daily feed consumption was higher in the full-fed chickens than in the restricted fed chickens by 30.1%. The results obtained in this research project are in line with Ukachukwu and Akapan (2007a) who reported that feed restriction in pullets depressed feed intake. The average feed consumption of a Koekoek chicken from 8 to 18 weeks was 70.7g per day for chickens that were full-fed (AA and AR) while an average daily feed intake for restricted fed chickens amounted to 51.29g. Feed restriction programme in the rearing phase was able to save a total of 26.5% of feed per bird in comparison with *ad libitum* feeding.

The initial two weeks of the laying phase indicate that Koekoek chickens from different treatments consumed feeds significantly different from one another. As presented in Table 3.7 the results demonstrate that chickens that were under the AA treatment consumed 15.7, 11.8 and 27.2g/d more ($p<0.05$) feed than those in the AR, RA and RR treatments respectively at the age of 19 weeks. At the age of 20 weeks, the daily feed consumption of birds in the RA treatment was higher than in the AA, AR and RR treatments by 1.7%, 28.5% and 28.3% respectively. The difference was higher ($p<0.05$) in the feed intakes of chickens that were full-fed and those that were feed restricted. The difference between the feed intake of Koekoek chickens in the AR and RR treatments were insignificant. The results of this study clearly showed that from the age of 21 weeks to the end of the experiment chickens that were fed restrictedly had on average lower ($p<0.05$) daily feed intake of 28.2% less than the full-fed chickens.

The total feed intake of birds in the RR treatment differed by 3, 0.08 and 2.9kg per bird from those in the AA, AR and RA treatments respectively. When considering the total amount of feed intake per bird from 8 to 32 weeks it can be seen as presented in Table 4.7 that Koekoek chickens in the AA treatment ate 18.6%, 9.2% and 28% more than those in the AR, RA and RR treatments respectively. The results of this study are in agreement with Ukachukwu and Akpan (2007a) who stated that feed intake appears to be a reflection of the amount of feed made available to the various groups of birds based on the percentage of restriction imposed on each group.

The findings of the current study are in agreement with the previous research reports that reflected a reduced feed intake in early-restricted fed birds (Tumova *et al.*, 2002 and Mohebodini *et al.*, 2009). In support of the results of the current study, Sekoni *et al.* (2002) concluded that restricted fed chickens consumed 30% less feed compared to the *ad libitum* fed ones. Turkeys subjected to restricted feeding had a reduced feed intake in comparison with birds raised on *ad libitum* feeding (Crounch *et al.*, 2002a).

Even though birds that were under AA and RA received the same amount of feed, birds under RA treatment increased their feed intake by 59.06g in a period of two weeks from 18 to 20 weeks while feed intake of birds in the AA treatment increased their feed intake by 31.92g. These results are in agreement with the findings of Naraharl *et al*. (1975) who stated that birds that have been restricted during rearing and then allowed to feed *ad libitum* during laying display increased daily feed intake. The birds that were previously feed restricted and later shifted to *ad libitum* feeding tend to eat more due to an increased appetite (Eitan and Soller, 2001). In support of these results Hassanabadi and Moghaddam (2004) reported that birds that were restricted at an early stage of their development increased their feed intake rapidly in order to get into what the intake would have been if they were not restricted. CIWF (2003) indicated that feed restricted broiler breeders consume their feed in a very short period of time and are chronically hungry and this is demonstrated by the fact that they are strongly motivated to consume feed at all times.

The feed intake of Koekoek chickens that were transferred from full feeding to restricted feeding (AR) increased to 84g per day during the laying period that represent 70% of the full-fed amount that was availed to them. These results disagree with the findings of Krueger (1987) who indicated that birds that were transferred from *ad libitum* feeding to restricted feeding resulted in significantly reduced feed intake. The feed intake of Koekoek chickens in RR treatment agrees with Eitan and Soller (2001) as they suggested that feed intake of the restricted fed chickens' increases between 20-22 weeks of age in restricted fed birds and the same results were observed in the current study. Crounch *et al.* (2002a) made an observation that the feed intake of restricted fed birds resulted in a saving in terms of feed costs and this observation was confirmed by the present study.

The feeding pattern of Koekoek chickens was affected by time of the year (season) as outlined in Table 3.12. The results indicate that Koekoek chickens consumed more feeds in winter than in summer during the growing phase effective from the 11th week of age. The results demonstrate that chickens that were kept in winter had a greater ($p<0.05$) feed intake compared to those raised during the summer. The observations of this study suggested that a Koekoek chicken kept in winter consumed between 48.3g and 78g per day from 10 to 18 weeks of age while a chicken in summer ate between 48.4g and 63g per day. The summer conditions suppressed the overall feed consumption by 12.9% during the rearing phase.

In the laying phase the results indicated that Koekoek chickens that were reared during the winter season ate more ($p<0.05$) layer mash compared to chickens in summer throughout the entire experimental period (19 to 32 weeks). On average chickens that were kept in winter had a daily feed intake ranging from 100.6g to 102g while Koekoek chickens that were kept in summer were consuming between 99.2g and 99.5g daily basis from 19 to 32 weeks.

The findings of the current study are confirmed by previous researchers who stated that the feed intake would be depressed due to high temperature in chickens (Plavnik and Yahav, 1998; Veldkamp *et al.*, 2000; 2005 and Lu *et al.*, 2007). This was observed in Koekoek chickens that were kept in winter, which ate significantly more than those kept in summer from the age of 11 to 18 weeks. On the other hand, the results on the feed consumption for the initial period (10 weeks) of the study contradict the earlier findings. The reason for variation can be attributed to the behavior of chickens when responding to low temperature. The rationale would be that during the early age, birds took more time huddled as a way of generating heat instead of eating. Since the rearing of Koekoek chickens in summer started in September and other group of chickens in March, it might be possible that at the beginning of September the temperatures were still low compared to the ones in March hence why Koekoek chickens on the summer treatment ate significantly more than in winter.

Bonnet *et al.* (1997) also stated a reduction of 30% in feed consumption during the summer season. In a study conducted in turkeys, it was discovered that temperature affected the feed intake of the birds to the point that there was a decline of 1.6 % in feed intake per a one degree Celsius increase (Veldkamp *et al.*, 2000; Blahova *et al.*, 2007 and Akyuz, 2009). Since chickens live comfortably in a narrowly thermo neutral zone the extreme temperatures either being low or high would negatively affect the feed intake of chickens hence why it was noted from this study that birds in winter clearly showed an increased appetite. The increased appetite in winter is also due to fact that birds would eat more as some of the feed consumed will be used for the chickens' heat generation.

Table 2.13: Feed intake per day (g/d) of Koekoek chickens reared either in summer or winter season during both rearing and laying phases

	Seasons		
Age (wks)	**Summer**	**Winter**	**S.E**
Rearing phase (10 - 18 weeks)			
(Weights, g)			
10	48.4	48.3	0.29
11	51.7[a]	52.2[b]	0.05
12	54.0[a]	55.5[b]	0.01
13	56.5[a]	58.0[b]	0.01
14	57.8[a]	62.1[b]	0.02
15	58.0[a]	78.0[b]	0.00
16	57.6[a]	78.0[b]	0.09
17	60.4[a]	77.93	0.15
18	63.0[a]	78.0[b]	0.02
Overall 10-18	3970[a]	4558[b]	3.00
Rearing phase (19 - 32 weeks)			
(Weights, g)			
20	99.2	100.6	0.18
21	99.2[a]	101.9[b]	0.04
22	99.5[a]	101.1[b]	0.11
23	99.5[a]	101.8[b]	0.06
24	99.2[a]	102.0[b]	0.02
25	99.2[a]	102.1[b]	0.03
26	99.4[a]	102.0[b]	0.00
27	99.2[a]	102.0[b]	0.02
28	99.3[a]	101.9[b]	0.04
29	99.2[a]	101.9[b]	0.03
30	99.4[a]	102.0[b]	0.02
31	99.4[a]	102.0[b]	0.01
32	99.4[a]	102.0[b]	0.00
Overall 19-32	905	9060	2.36
Overall 10-32	1303[a]	13620[b]	3.65

[ab] Means within a row with no common superscript differ significantly p<0.05), S.E-standard error

The results indicate the interaction between the feeding level and the season of the year excluding the 10[th] week. The highest feed intakes were recorded in chickens that were in the AA and AR treatments in winter while the lowest feed intake was observed in chickens that were in the RA and RR treatments in summer. The accumulated daily feed consumption differences in the AA, AR, RA and RR treatments in winter and summer were 725, 713, 463 and 451g respectively during the rearing phase. The difference was much higher in the full-fed chickens than in the restricted fed groups.

At 20 weeks of age, it was observed that Koekoek chickens that were in the AA and RA treatments in winter ate more than those that were in other treatments. During the same period, the lowest feed intake was recorded in chickens that were in the AR and RR treatments regardless of the rearing season with the average feed intake ranging from 82.8g to 84g per day. This implies that chickens that were fed restrictedly were able to consume all the feed they were fed. The chickens that were fed *ad libitum* in summer had a daily average feed intake ranging from 114g to 115.9g. Similar results were noticed for the whole study period (19 to 32 weeks) of Koekoek chickens during the laying phase. The overall feed intakes for the period of 14 weeks show that the chickens in the AA and RA treatments in winter were higher than in winter by 1.7% and 0.5% respectively. In the AR and RR treatments, the feed intake was higher in summer with the difference of 0.2% and 2.3% between summer and winter. The reason for the feed intake differences in Koekoek chickens that were full fed but kept in different seasons could be due to a reduced amount of feed intake in chickens during the summer season because of the increased environmental temperature in a way to control their body temperatures.

In view of the total feed intake for the entire research study the findings portrayed that Koekoek chickens that were in the AA treatment had higher feed intake in spite of the season while those in the RR treatment ate the lowest amount regardless of the season. Koekoek chickens that were changed from either restricted feeding to full feeding (RA) or visa versa (AR) in winter consumed more than those in summer. In the AR and RA treatments the feed consumption in winter deviated by 5.3% and 3.6% from that in winter. These results also portray that Koekoek chickens will have lower daily feed intake when shifted from full feeding to restricted feeding during the laying phase as opposed to shifting from restricted feeding in the rearing phase to full feeding during the laying phase.

Table 2.14: Effect of the interaction between feeding level and season on feed intake per day (g/d) of Koekoek chickens

	Treatment*Season																
Age (wks)	**SAA**	**S.E**	**WAA**	**S.E**	**SAR**	**S.E**	**WAR**	**S.E**	**SRA**	**S.E**	**WRA**	**S.E**	**SRR**	**S.E**	**WRR**	**S.E**
10	54.7	0.91	53.7	0.83	54.71	0.87	54.7	0.79	42.1	0.77	43.5	0.87	42.1	0.78	41.9	0.86
11	58.7^{a}	0.24	61.0^{b}	0.22	58.68^{a}	0.23	60.9^{b}	0.21	42.6^{a}	0.20	43.4^{b}	0.23	42.6^{a}	0.20	43.4^{b}	0.23
12	62.0^{a}	0.04	65.0^{b}	0.03	62.0^{a}	0.04	65.0^{b}	0.04	46.0^{a}	0.36	46.0^{b}	0.04	46.0^{a}	0.04	46.0^{b}	0.04
13	65.1^{a}	0.04	68.0^{b}	0.04	65.1^{a}	0.04	68.0^{b}	0.04	48.0^{a}	0.04	48.0$_{b}$	0.04	48.0^{a}	0.04	48.0^{b}	0.04
14	66.6^{a}	0.07	75.1^{b}	0.07	66.6^{a}	0.07	75.1^{b}	0.06	48.9^{a}	0.06	49.2^{b}	0.07	48.9^{a}	0.06	49.1^{b}	0.07
15	67.0^{a}	0.01	93.0^{b}	0.01	67.0^{a}	0.01	93.0^{b}	0.01	49.0^{a}	0.01	63.0^{b}	0.01	49.0^{a}	0.01	63.0^{b}	0.01
16	66.48^{a}	0.28	92.9^{b}	0.25	66.4^{a}	0.26	92.7^{b}	0.23	48.8^{a}	0.23	63.3^{b}	0.26	48.8^{a}	0.24	63.3^{b}	0.26
17	70.11^{a}	0.47	92.6^{b}	0.42	70.4^{a}	0.44	92.0^{b}	0.40	10.5^{a}	0.40	63.6^{b}	0.45	50.5^{a}	0.40	63.6^{b}	0.44
18	72.96^{a}	0.06	93.0^{b}	0.06	73.0^{a}	0.06	93.0^{b}	0.05	53.0^{a}	0.05	63.0^{b}	0.06	53.0^{a}	0.05	63.0^{b}	0.06
10-18	4579^{a}	9.55	5304^{b}	8.64	4584^{a}	9.06	5297^{b}	8.23	3359^{a}	8.09	3822^{b}	9.08	3359^{a}	8.18	3810^{b}	9.01
19	114.7^{a}	0.86	8664.5^{b}	0.78	84.1^{a}	0.82	85.9^{b}	0.75	114.9^{a}	0.73	62.9^{b}	0.82	84.1^{a}	0.74	62.9^{b}	0.82
20	116.1^{a}	0.56	113.8^{b}	0.50	85.2^{a}	0.53	82.2^{b}	0.48	115.9^{a}	0.47	118.1^{b}	0.53	85.0^{a}	0.48	82.8^{b}	0.52
21	114.4^{a}	0.13	119.6^{b}	012	84.0^{a}	0.12	84.0^{b}	0.11	114.4^{a}	0.11	120.0^{b}	0.12	84.0^{a}	0.11	84.0^{b}	0.12
22	114.8^{a}	0.35	118.1^{b}	0.32	84.3^{a}	0.34	83.6^{b}	0.31	114.6^{a}	0.30	119.1^{b}	0.34	84.2^{a}	0.30	83.7^{b}	0.33
23	114.7^{a}	0.18	119.8^{b}	0.16	84.2^{a}	0.17	83.8^{b}	0.15	114.7^{a}	0.15	119.8^{b}	0.17	84.2^{a}	0.15	83.8^{b}	0.17
24	114.4^{a}	0.05	120.0^{b}	0.04	84.0^{a}	0.05	84.0^{b}	0.04	114.3^{a}	0.04	120.0^{b}	0.05	84.0^{a}	0.04	84.0^{b}	0.09
26	114.8^{a}	0.01	120.0^{b}	0.01	84.0^{a}	0.01	84.0^{b}	0.01	114.8^{a}	0.01	120.0^{b}	0.01	84.0^{a}	0.01	84.0^{b}	0.01
27	114.7^{a}	0.07	120.0^{b}	0.07	84.1^{a}	0.07	84.0^{b}	0.06	114.7^{a}	0.06	120.0^{b}	0.07	84.0^{a}	0.06	83.9^{b}	0.07
28	114.3^{a}	0.11	119.9^{b}	0.10	84.1^{a}	0.10	83.9^{b}	0.01	114.7^{a}	0.09	119.9^{b}	0.10	84.1^{a}	0.09	83.9^{b}	0.10
29	114.2^{a}	0.08	119.9^{b}	0.07	84.1^{a}	0.08	83.9^{b}	0.07	114.6^{a}	0.07	119.9^{b}	0.08	84.1^{a}	0.07	83.9^{b}	0.08
30	114.5^{a}	0.05	120.0^{b}	0.05	84.1^{a}	0.05	84.0^{b}	0.05	114.8^{a}	0.05	120.0^{b}	0.05	84.0^{a}	0.05	84.0^{b}	0.05
31	114.8^{a}	0.02	120.0^{b}	0.02	84.0^{a}	0.02	84.0^{b}	0.02	114.8^{a}	0.02	120.0^{b}	0.02	84.0^{a}	0.02	84.0^{b}	0.02
32	114.8^{a}	0.01	120.0^{b}	0.01	84.0^{a}	0.01	84.0^{b}	0.01	114.8^{a}	0.01	120.0^{b}	0.01	84.0^{a}	0.01	84.0^{b}	0.01
19-32	1044^{a}	7.40	1062.^{b}	6.70	765.9^{a}	7.01	763.9^{b}	6.37	1045^{a}	6.27	1050^{b}	7.03	765.7^{a}	6.33	748.2^{b}	6.98
10-32	1503a	11.65	1593^{b}	10.54	1226^{a}	11.05	1294^{b}	10.04	1380^{a}	9.87	1432^{b}	11.08	1102^{a}	9.98	1129^{b}	11.00

^{ab} Means within a row with no common superscript differ significantly ($p<0.05$ and $p<0.05$).

Footnote:

SAA-full feeding during rearing and laying in summer season. SAR-full feeding during rearing and restricted during laying in summer season, SRA-restricted feeding during rearing and full feeding during laying in summer season, SRR-restricted during rearing and laying in summer season, WAA-full feeding during rearing and laying in winter season. WAR-full feeding during rearing and restricted during laying in winter season, WRA-restricted feeding during rearing and full-feeding during laying in winter season, WRR-restricted during rearing and laying in winter season, S.E-standard error.

Table 2.15: Feed conversion ratio of Koekoek chickens that were subjected to different feeding level treatments

			Treatment		
Age (weeks)	**AA**	**AR**	**RA**	**RR**	**S.E**
Rearing Phase (10 -18weeks)					
10	3.5^{a}	3.5^{a}	4.2^{b}	4.0^{b}	0.05
12	3.7	3.7	3.9	4.0	0.05
14	5.4^{a}	6.5^{a}	7.3^{b}	7.4^{b}	0.20
16	5.4^{a}	5.1^{a}	8.0^{b}	7.8^{b}	0.09
18	5.0^{a}	4.7^{a}	6.3^{b}	6.3^{b}	0.10
10-18	5.5^{a}	5.4^{a}	6.8^{b}	6.7^{b}	0.60
Laying Phase (20-32weeks)					
20	7.4^{a}	11.8^{b}	4.4^{c}	6.2^{d}	0.17
22	9.9	-6.1	11.4	12.0	5.10
24	10.8^{a}	21.3^{b}	6.7^{c}	8.9^{a}	0.35
26	11.8^{ab}	27.2^{c}	9.5^{a}	12.4^{b}	0.46
28	22.3	15.7	7.3	14.8	3.63
30	47.8^{a}	-60.0^{b}	34.5^{a}	55.3^{a}	4.59
32	65.3	-6.6	8.4	-2.01	17.09
20-32	15.0^{a}	46.3^{b}	9.4^{a}	15.8^{a}	3.47
10-32	8.9^{a}	11.0^{b}	7.5^{c}	9.1^{a}	0.03

[abcd] Means within a row with no common superscript differ significantly ($p<0.05$).
Footnote:
AA-full feeding during rearing and laying. AR-full feeding during rearing and restricted during laying, RA-restricted feeding during rearing and full feeding during laying, RR-restricted during rearing and laying, S.E-standard error.

Results shown in Table 3.14 indicate the significant difference in FCR between Koekoek chickens that were full-fed and those that were feed restricted during the growing phase. Koekoek chickens that were in the AA and AR treatments were more efficient in feed conversion than those in the RA and RR treatments by 14.6% at the age of 10 weeks. The same trend of the results was observed throughout the growing phase and the only exception was at the 12th week of which the FCR difference between the different feeding levels was not significant. The overall FCR scores for full-fed and restricted fed chickens were 5.5 and 6.8 respectively during the rearing phase. The results of this study suggest that full-fed chickens converted feeds into body weight better than feed restricted chickens.

During the laying phase Koekoek chickens that were in the RA treatment had better ($p<0.05$) feed conversion ratio from the first oviposition up to the end of the experiment (32 weeks) than chickens that were in other treatments (AA, AR and RR). When looking at the overall FCR for the laying period (20-32 weeks) it was seen that chickens that were subjected to the RA treatment were more efficient in feed coversion than chickens that were in the AA, AR and RR treatments by 37.3%, 79.7% and 40.5%

respectively. The FCR of the chickens in the RA treatment improved by 18.7%, 46.7% and 21.3% more than in the AA, AR and RR treatments respectively for the entire study (10 to 32 weeks).

The findings of this study are not in line with Farhat *et al.* (1986) who reported that restricted feeding resulted in slower feed passage rate (FPR) through the digestive system hence an increase in the utilization of feed. Farhat *et al.* (1986) further argued that feed restriction lengthens the time in which the feeds are in contact with the enterocytes and as a result, the nutrient absorption will improve. The fact that chickens that were subjected to the RA treatment were able to convert more feed into weight is supported by the findings of Farhat *et al.* (1986) who stated an increase in FCR when restricted feeding is followed by *ad libitum* feeding in chickens. Farhat *et al.* (1986) also mentioned that a feed restriction of 25% in layers would yield better results in terms of compensatory growth and feed conversion ratio.

The findings of this study indicate a significant difference between the seasons of summer and winter in feed conversion efficiency of Koekoek chickens (Table 3.15). The results indicate that chickens that were raised in summer were more efficient in conversion of feeds into body development as compared to chickens that were raised in winter. It was observed that the feed conversion ratio was better ($p<0.05$) in chickens reared in summer compared to those kept in winter and the same pattern of results was observed throughout the rearing period (10-18 weeks). The summer conditions improved ($p<0.05$) the overall FCR for the rearing phase by 43.6%.

During the laying period (20 to 32 weeks) the results show that Koekoek chickens that were kept in summer were not different ($p>0.05$) from chickens that were kept in winter for the entire laying period except during the 32nd week of age. However, even though the FCR values were not statistically different, one would recognize that Koekoek chickens that were subjected to warm environment conditions had lower FCR for the entire laying period of the study as compared to chickens that were reared in winter. At the age of 32 weeks Koekoek chickens that were under summer treatment had better (224.1) FCR as compared to the ones that were subjected to winter conditions (-191.00) at 0.05 siginficant level. When looking at an average feed conversion ratio from 10 to 32 weeks, the results show the difference ($p<0.05$) of 30% between the chickens reared in summer and winter with the latter having a higher FCR.

Table 2.16: Feed conversion ratio (FCR) of Koekoek chickens reared in either summer or winter during both rearing and laying phases

	Season		
Age (wks)	**Summer**	**Winter**	**S.E**
Rearing phase (10 - 18 weeks)			
10	0.4^{a}	7.1^{b}	0.24
12	2.4^{a}	5.2^{b}	0.44
14	6.8	6.5	0.23
16	5.3^{a}	7.9^{b}	0.15
18	6.5^{a}	7.8^{b}	0.07
10-18 weeks	4.4^{a}	7.8^{b}	0.15
Laying phase (20 - 32weeks)			
20	8.8	6.1	0.56
22	-41.7	55.3	0.23
24	10.1	13.7	0.49
26	13.1	16.5	1.10
28	32.7	-2.5	1.95
30	5.3	33.5	13.39
32	224.1^{a}	-191.0^{b}	34.51
Overall 20-32	31.5	23.9	6.67
Overall 10-32	7.9^{a}	10.5^{b}	0.07

^{ab} Means within a row with no common superscript differ significantly ($p<0.05$), S.E-standard error.

These results are confirmed by the findings of Akyuz (2009) who reported a better-feed conversion ratio of chickens raised in summer than those kept in winter. According to Faria *et al.* (2005), chickens raised under high temperature would perform better than those exposed to cold temperature but lower than the ones kept under a thermo-neutral environment. The results of the present study indicate that exposure of chickens to cold environment greatly affected their feed conversion ratio (FCR) and this is in accordance with Blahova *et al*. (2007) who conducted their study in a more or less similar environmental condition to Lesotho. In their study, the low temperature was between 4 and 13°C while the thermo-neutral environment would be from 21 to 24°C. Mendes *et al.* (1997) also concluded that chickens that were under either cold or hot temperature had high feed conversion ratio as compared with those under thermo-neutral conditions. In another study, which was done on turkeys, Veldkamp *et al*. (2000) indicated that the feed conversion ratio was better in turkeys that were kept under high temperature as opposed to their counterparts. However, the findings of Bonnet *et al.* (1997), Veldkamp *et al.* (2005) and Lu *et al.* (2007) reported an improved feed conversion ratio in birds kept in low temperatures as opposed to those kept in high temperatures. The insignificant differences between chickens that were kept in summer and winter can be because chickens had fully developed their feathers at this stage hence the feeds given to chickens in winter were converted to body weight rather than keeping birds warm as in growing chicks.

The results indicated that there was an interaction between the feeding level and the season at the 10th, 12th and 18th weeks of age (Table 3.16). The overall performance in the rearing phase also reveals that the chickens in summer were efficient in feed conversion. The performance of the chickens in the AA, AR, RA and RR treatments in summer were more efficient than in winter by 50.5%, 50.3%, 37.8% and 37.4% respectively. The difference between the chickens raised in summer and winter was higher in the AA and AR treatments in comparison with those in the RA and RR treatments. In general, these results signified the efficiency of chickens kept in summer in converting feed into muscles more than in winter.

At the age of 32 weeks, the results indicate that Koekoek chickens ate more to gain body weight in all treatments as compared to the time when chickens were still young. The best ($p<0.05$) FCR (172.3) was seen in chickens that were in the AR treatment in summer while those that were in the RR treatment in winter had the negative FCR (-230). Chickens in the AA, RA and RR treatments in summer had the FCRs of 277.6, 220.2 and 226 respectively. This indicates that chickens in those treatments were growing very slowly during the last two weeks of this study. This can be supported by the fact that at peak laying period chickens have a tendeny to gain less weight as a characteristic of laying chicken. A negative FCR in the AA (-147), AR (-185), RA (-203) and RR (-230) treatments in winter is alleged to have been contributed by the impact of low temperature and high laying percentage of chickens at this period. It is contemplated that during the laying period a lot of feed is converted into egg laying instead of weight gain hence a negative feed conversion.

The total FCR still reflects that chickens that were in the AA, AR, RA and RR treatments in summer were 32.1%, 15.1% and 19% more efficient in converting feeds than in winter. The findings of the present study suggest that the better FCR results were obtained when feed restricting chickens in summer as compared to feeding chickens unlimitedly in winter. As reflected in these results the highest FCR was observed in chickens that were in the AR treatment in winter and this means that shifting chickens from full feeding to restricted feeding (AR) compromised their efficiency in converting feed into body weight as opposed to shifting from restricted feeding to full feeding (RA). The results of this study also revealed that Koekoek chickens that were feed restricted for the entire study (RR) in winter ate less feed to gain weight in comparison to those that were only feed restricted during the laying phase (AR) irrespective of being raised in either winter or summer.

Table 2.17: Effect of the interaction between feeding level and season on feed conversion ration of Koekoek chickens

	Treatment*season															
Age (wks)	**SAA**	**S.E**	**WAA**	**S.E**	**SAR**	**S.E**	**WAR**	**S.E**	**SRA**	**S.E**	**WRA**	**S.E**	**SRR**	**S.E**	**WRR**	**S.E**
10	- 0.1[a]	0.32	7.0[b]	0.29	0.1[a]	0.31	6.9[b]	0.28	1.0[a]	0.27	7.4[b]	0.31	0.7[a]	0.28	7.2[b]	0.30
12	1.9[a]	0.35	5.4[b]	0.31	2.0[a]	0.33	5.4[b]	0.30	2.8[a]	0.29	3.0[b]	0.30	5.0[a]	0.33	3.0[b]	0.30
14	5.8	1.28	5.1	1.16	7.4	1.21	5.6	1.10	6.9	1.08	7.6	1.22	7.2	1.09	7.7	1.21
16	-4.2	0.58	6.6	0.52	3.6	0.55	6.6	0.50	6.7	0.49	9.4	0.55	6.6	0.49	9.4	0.55
18	5.7	0.63	4.3	0.57	5.3	0.59	4.1	0.54	7.4	0.53	5.1	0.59	7.4	0.54	5.2	0.59
10-18	3.6[a]	0.18	7.3[b]	0.16	3.6[a]	0.17	7.2[b]	0.16	5.2[a]	0.15	8.4[b]	0.17	5.1[a]	0.15	8.2[b]	0.17
20	9.1	1.07	5.7	1.01	11.5	1.01	12.2	0.96	6.2	0.90	2.8	1.06	8.5	0.91	3.8	1.06
22	-37.5	31.47	57.3	29.60	-66.6	29.80	54.3	28.32	-33.2	26.57	56.0	31.09	-29.4	26.86	53.4	31.21
24	8.4	2.17	13.2	2.04	20.9	2.06	21.7	1.95	3.7	1.83	9.8	2.15	7.6	1.85	10.20	2.15
26	11.8	2.83	11.8	2.67	26.5	2.68	27.8	2.55	7.2	2.39	11.8	2.80	10.3	2.42	14.4	2.81
28	47.7	22.39	-3.0	21.06	14.5	21.21	16.9	20.15	31.2	18.91	-16.5	22.12	37.4	19.11	-7.7	22.21
30	17.4	28.34	78.3	26.66	-44.1	26.84	-75.9	35.50	9.9	23.93	59.2	28.00	38.3	24.19	72.2	28.11
32	277.6	105.50	-147.0	99.24	172.3	99.92	-185.0	94.93	220.2	89.07	-203.0	104.24	226.1	90.05	-230.0	104.64
20-32	10.2	21.40	19.5	20.13	94.0	20.27	46.2	19.26	6.2	18.07	13.3	21.14	15.5	18.27	16.5	21.22
10-32	7.2	0.19	10.6	0.18	10.1	0.18	11.9	0.18	5.8	0.16	9.3	0.19	8.1	0.17	10.0	0.19

[ab] Means within a row with no common superscript differ significantly ($p<0.05$)

Footnote:

SAA-full feeding during rearing and laying in summer season. SAR-full feeding during rearing and restricted during laying in summer season, SRA-restricted feeding during rearing and full feeding during laying in summer season, SRR-restricted during rearing and laying in summer season, WAA-full feeding during rearing and laying in winter season. WAR-full feeding during rearing and restricted during laying in winter season, WRA-restricted feeding during rearing and full-feeding during laying in winter season, WRR-restricted during rearing and laying in winter season, S.E-standard error.

The results on mortality are non-significant between Koekoek chickens that were under different feeding regimes (Table 2.17). During the growing phase (10 to 18 weeks) the total mortality in birds that were full-fed (AA and AR) was 3.7% while the mortality of restricted fed Koekoek chickens (RA and RR) was 2%. Even though the results obtained from the present study reflect insignificant mortality rate of full-fed chickens compared to those that were allotted to restricted feeding it was noticed that full-fed chickens had 1.7% more death incidents than restricted fed ones.

During the laying phase, the death rate in Koekoek chickens was 2.5%, 1.6% , 1.6% and 1.9% for birds in treatments AA, AR, RA and RR respectively. As observed in Table 3.17 Koekoek chickens that were full-fed for the entire study (AA) had an insignificantly higher number of dead chickens compared to those that were in other treatments ($p>0.05$).

Table 2.18: Mortality (%) of Koekoek chickens that were subjected to different feeding level treatments

			Treatments		
Age	**AA**	**AR**	**RA**	**RR**	**S.E**
10 – 18 weeks **(**rearing phase**)**	2.98	4.29	1.43	2.50	0.73
20 -32 weeks (laying phase)	2.51	1.59	1.59	1.85	0.57

Food note:
AA-full feeding during rearing and laying. AR-full feeding during rearing and restricted during laying, RA-restricted feeding during rearing and full feeding during laying, RR-restricted during rearing and laying, S.E-standard error.

The results obtained from this study on the rearing phase are in agreement with Tottori *et al.* (1997); Lippens *et al*. (2000) and Robert (2009) who indicated that feed restriction is effective in controlling mortality. Balnave (1984) also demonstrated that a feed restriction of 25 to 50% could reduce mortality in birds. The results of the present study suggest that a 30 percent feed restriction slightly lowered the mortality rate in Koekoek chickens. This slight decrease in the death rate of chickens that were under restricted feeding cannot be underestimated as this would a mean a lot to a subsistence farmer in the rural village in Lesotho.

During the laying phase, the results of this study contradict previous findings that stated that the higher percentage of mortality in the full-fed chickens could possibly result from high body weight that is associated with pathological conditions and metabolic disorders such as ascites (Farhat *et al.*, 1986; Tolkamp *et al*., 2005 and Mahmood *et al*., 2007). CIWF (2003) stated that *ad libitum* fed breeding chickens are more prone to obesity, thermal discomfort, lameness as well as skeletal disorders, heart failure and excessive body weight that are all associated with reduced disease resistance. Naraharl *et al*. (1975) stated that mortality is reduced from 19.3 to 10.5% in crossbred strains when restricted feeding follows *ad libitum* feeding. Lippens *et al*. (2000) suggested that a mild feed restriction might offer economic advantage by decreasing mortality, and better feed conversion efficiency. The reason for the results of the present study differing from the previous ones could be attached to the different types of chicken breeds studied. Koekoek chickens can survive even under adverse management as opposed to exotic commercial breeds, which are more vulnarable.

During the growing phase, which is from 10 to 18 weeks the results clearly showed that Koekoek chickens that were allocated to winter treatment increased mortality by 3% (3.18). During the laying phase (19 to 32 weeks), the results show the insignificant differences in the mortality rates of Koekoek chickens that were subjected to different seasons. However, Koekoek chickens that were subjected to winter conditions had a higher percentage (2.8 %) of dead chickens compared to the mortality rate of less than 1% (0.9%) in chickens that were reared in summer. The reason behind the insignificant mortality rate differences could likely be attributed to the feather coverage of chickens at this production stage.

Table 2.19: Mortality percentage of Koekoek chickens that were reared in either summer or winter during both rearing and laying phases

	Season		
AGE	**Summer**	**Winter**	**S.E**
8-18	1.13^{a}	4.46^{b}	0.71
19-32	0.93	2.84	0.59

^{ab} Means within a row without a common superscript differ significantly ($p<0.05$) , S.E- Standard Error

In support of these results, Cooper and Washburn (1998) reported the low mortality of chickens that were either kept in high or moderate temperature. The other factor for the lower mortality can also be attributed to the fact that Koekoek chickens are believed to be hardy and adaptable to the local environmental conditions as reported by Joubert (1996). However, the previous findings of Petracci *et* *al.* (2006) recorded a higher number of deaths in summer as compared to winter in both turkeys and broilers, which could be explained by the high environmental temperature and hence the occurrence of heat stress. The explanation for Koekoek chickens in winter to die more than those in summer could possibly be attached to the type of the housing chickens were kept in. This can further be argued by the fact that the corrugated iron sheets are extremely cold in winter especially at night bearing in mind that the temperatures in Lesotho can drop below 0^oC. It was also observed that at the age of 8 weeks, the chickens' feathers were still developing and hence why chickens were more susceptible to coldness.

The results of the present study show an insignificant effect of the interaction between feeding level and season on the mortality rate of Koekoek chickens during both rearing and laying phases (Table 3.19). However, the records demonstrate that Koekoek chickens that were reared in winter irrespective of whether they were full fed or restricted fed had insignificantly highest mortality rate ($p>0.05$). This implies that the effects of chickens' mortality rate in the present study can be linked more to the low winter temperatures while the feeding level seems to have contributed very little.

Table 2.20: Effect of the interaction between feeding level and season on mortality (%) of Koekoek chickens

	Treatment* season															
Age	**SAA**	**S.E**	**WAA**	**S.E**	**SAR**	**S.E**	**WAR**	**S.E**	**SRA**	**S.E**	**WRA**	**S.E**	**SRR**	**S.E**	**WRR**	**S.E**
8-18	1.67	2.06	4.29	1.91	1.42	1.91	8.57	1.91	1.42	1.91	1.42	1.91	0.00	2.06	5.00	2.06
19-32	1.85	1.76	3.17	1.63	0.00	1.63	3.17	1.63	0.00	1.63	3.17	1.63	1.85	1.76	1.85	1.76

Footnote:

SAA-full feeding during rearing and laying in summer season. SAR-full feeding during rearing and restricted during laying in summer season, SRA-restricted feeding during rearing and full feeding during laying in summer season, SRR-restricted during rearing and laying in summer season, WAA-full feeding during rearing and laying in winter season. WAR-full feeding during rearing and restricted during laying in winter season, WRA-restricted feeding during rearing and full-feeding during laying in winter season, WRR-restricted during rearing and laying in winter season, S.E-standard error.

2.4 Conclusion

- Full feeding during the rearing phase improved ($p<0.05$) body weight, weight gain, feed intake and FCR compared to restricted feeding.
- Early feed restriction followed by full feeding (RA) resulted in higher body weights, weight gain and FCR compared to the other treatments tested in this experiment.
- The feeding level did not have any effect on the mortality rate of Koekoek chickens.
- Rearing Koekoek chickens in winter is more risky in terms of mortality rate.
- Summer conditions resulted in better body weights, weight gain, FCR and less feed intake.
- 70 percent feed restriction during the rearing phase followed by full feeding in the laying phase (RA) in summer is the most profitable strategy.

2.5 Recommendations

- It is recommended that farmers who intend to keep Koekoek chickens beyond 18 weeks of age to feed them restrictedly during the rearing and shift to full feeding during the laying phase (RA).
- In the case where chickens are reared exclusively for the purpose of meat consumption and with the intention of slaughtering the birds at an earlier age, full feeding (AA and AR) in the rearing phase would be the best feeding management option.
- In order to capitalize on body weight, FCR and to lower mortality rates it is best to raise Koekoek chickens in summer.

2.6 References

Aksit, M., S. Yalcin, S. Ozkan, K. Metin and D. Ozdemir. 2006. *Effects of temperature during rearing and crating on stress parameters and meat quality of broilers*. Poultry Science 85: 1867-1874.

Akyuz, Adil. 2009. *Effects of some climates parameters of environmentally uncontrollable broiler houses on broiler performance*. Journal of Animal and Veterinary Advances 8 (12): 2608 - 2612.

Balnave, D. 1984. *The Influence of body weight at point-of-lay on the production responses of restricted-reared pullets. Aust.* J. Agric. 845-9

Blahova J, R. Dobsikova, E. Strakova and P. Suchy. 2007. *Effect of low environment temperature on performance and blood system in broiler chickens (* ***Gallus domesticus****)*. ACTA vet 76: S17-S23.

Bonnet S, P.A. Geraert, M. Lessire, B. Carre and S. Guillaumin. 1997. *Effect of high ambient temperature on feed digestibility in broilers.* Poultry Science 76: 857-863

Bruggeman V. O. Onagbesan, E.D' Hondt, N. Buys, M. Safi, d. Vanmont fort, L. Beghman, F. K. Vandesande and E. Decuypere. 1999. *Effects of timing and duration of feed restriction during rearing on resproductive characteristics, in broiler breeder females.* Poultry Science 78:1424-1434.

CIWF .2003. *Feed Restriction of Broiler*. Breeds.Gorillasoft Printable: United Kingdom.

Colin, G. Scanes, Geoge Brant and M. E. Ensminger (1992*). Poultry Science*. Peason Printice Hall: United States of America.

Cooper M.A and K.W. Washburn. 1998. *The relationships of body temperature to weight gain, feed consumption and feed utilization in broilers under heat stress.* Poultry Science 77: 237-242.

Crounch, Andrew Nell. 2000. *The effects of physical feed restriction on body composition and reproductive performance of commercially Large white. Department of Poultry Science Poultry Science programturkey breeder hens and its subsequent economic impa*ct: Raleigh.

Crounch, A.N., J.L. Grimes, V.L. Christensen and K.K. Krueger. 2002a. *Effect of physical feed restriction during rearing on large white turkey breeder hens. 1. Growth performance.* Poultry Science 81:9-15.

Deeb, N and A. Cahaner. 1999. *The effects of naked-neck genotypes, ambient temperature and feeding status and their interactions on body temperature and performance of broilers.* Poultry Science 78: 1341-1346.

Deeb, N and A. Cahaner. 2001a. *Genotype by environment interaction with broiler genotypes differing in growth rate. The effects of high temperature on dwarf versus normal broilers*. Poultry Science 80: 541-548.

Deeb, N and A. Cahaner. 2001b. *Genotype by environment interaction with broiler genotypes differing in growth rate. 1. The effects of high ambient temperature and naked neck genotype on lines differing in genetic background.* Poultry Science 80: 695-702.

Douglas, C., and M.D. Quart. 1992. *Management of small flocks*. Florida Cooperative Extension Services, Institute of Food and Agricultural Sciences, University of Frorida, Gainesville.

Duncan, D.B. 1955. *Multiple range and multiple F. tests*. Biometrics 11: 1-42

Eitan, Y and M. Soller. 2001. *Effect of photoperiod and quantitative feed restriction in a broiler strain on onset of lay in females and onset of semen production in males: A genetic hypothesis*. Jerusalem: Israel. Poultry Science 82:1163–1169.

Farhat, A., S. Lavallee, E. R. Chavez, S. P. Touchburn, P. C. Lague. 1986. *Reproductive performance of F1 Pekin duck breeders selected with ultrasound scanning for breast muscle thickness and the effect of selection on F2 growth and muscle measurement.* Research Reports, Department of Animal Science, McGill University, Montreal, QC, Canada. Page 64-66.

Faria Filho, D.E., P.S. Rosa, B.S. Vieira, M. Macari. R.L Furian. 2005. *Protein levels and environmental temperature effects on carcass characteristic, performance and nitrogen excretion of broiler chickens from 7 to 21 days of age.* Brazilian Journal of Poultry Science 5(4):247-253.

Fontana, E.A., Weaver WD Jr, Watkins BA, Denbow DM. 1992. *Effect of early feed restriction on growth, feed conversion and mortality in broiler chickens.* Poultry Science 1: 296-305.

Hassan, S.M., M. E. Mady, A. L. Cartwright, H. M. Sabri and M. S.Mobarak. 2003. *Physiology and reproduction: Effect of early feed restriction on reproductive performance in Japanese Quail (Coturnix coturnix japonica) Ismailia,* Egypt. Poultry Science 82:1163–1169.

Hassanabadi, A and H. Nassiri Moghaddam. 2004. *Effect of early feed restriction on performance characteristics and serum thyroxin of broiler chickens.* International Journal of Poultry Science 5 (12): 1156-1159.

Khetani, L. T., T. T. Nkukwana M. Chimonyo and V. Muchenje. 2008. *Effect of quantitative feed restriction on broiler performance*. Tropical Animal Health and Production 41(3): 379-384.

Krueger, K.K. 1987. *Managing genetic gain.* California Animal Nutrition Conference, Fresno, CA.

Olanrewaju, H.A., J.L. Purswell, S.D. Collier and S.L. Branton. 2010. *Effect of Ambient temperature and light intensity on growth performance and carcass characteristics of heavy broiler chickens at 56 days od age*. International Journal of Poultry Science 9 (8): 720-725

Leeson, S. and L.J. Caston. 1993. *Does environmental temperature influence body weight: Shank length in leghorn pullets?* Journal of Applied Poultry Res.2: 245-248

Lippens , M., G. Room , De Groote and Decuypere E. 2000. *Early and temporary quantitative food restriction of broiler chickens. Effects on performance characteristics, mortality and meat quality.* British Poultry Science 41:343-354.

Lu, Q., J. Wen and H. Zhang. 2007. *Effect of chronic heat exposure on fat deposition and meat quality in two genetic types of chicken*. Poultry Science 86: 1059-1064.

Mahmood, S. Mehmood, F.Ahamad, A. Masoodi and R. Kuasar. 2007. *Effects of feed restriction during starter phase on subsequent growth performance, dressing percentage, relative organ weights and weight and immune response of broilers.* Pakistan Vet J. 27(3): 137-141.

Mendes A.A., S.E. Watkins, J.A. England, E.A. Saleh, A.L. Waldroup and P.W.Waldroup. 1997. *Influence of dietary lysine levels and arginine: Lysine ratios on performance of broiler exposed to heat or cold stress during the period of three to six weeks of age*. Poultry Science 76: 472-481.

Mohebodini H, B. Dastar, M. Shams Sharg and S. Zerehdaran. 2009. *The comparison of early feed restriction and meal feeding on performance, carcass characteristics and blood constituents of broiler chickens.* Journal of Animal and Veterinary Advances 8 (10): 2069-2074.

Naraharl, D., C.V. Reddy and S.M. Siddiqui.1975. *Restricted feeding of growing pullets at different levels and durations, effect on egg production, egg quality and profits*. Indian Journal Poultry Science 10: 10-18.

Nthimo, A. M. 2004. *The phenotypic characterization of native Lesotho chickens.* Bloemfontein

Petracci M., M. Bianchi, C. Cavani, P.Gaspari and A. Lavazza. 2006. *Preslaughter mortality in broiler chickens, turkeys, and spent hens under commercial slaughtering.* Poultry Science 85: 1660-1664.

Plavnik, I. and S. Yahav. 1998. *Effect of environmental temperature on broiler chickens subjected to growth restriction at an early age.* Poultry Science 77: 870-872.

Reem, Y. and A. Cahaner. 1999. *The effects of naked-neck (Na) Frizzle (F) genes on growth and meat yield of broilers and their interactions with ambient temperatures and potential growth rate*. Poultry Science 78: 1347-1352.

Robert, Czirjak. 2009. *Effect of Feed Restriction on Growth in Broiler Chickens.* Roman: Oradea.

Sekoni, A .A., I. A. Adeyinke and S. O. Ogundipe. .2002. *The effect of quantitative feed restriction on pullet development and subsequent egg production*. Tropical Journal of Animal Science 5 :(2) 19-26.

Sogut, Bunyamin and Osman Kalpak 2009. *Effect of Feed Restriction on Growth performance of Japanese Quail.* Volume 8 Number 079-1092.

Steel, R.G.D. and J.H. Torrie, 1980. *Principles and Practice of Statistics. A Biometric* Approach. 2nd Edn., McGraw-Hill Book Co. Inc., New York.

Tesfaye, E., B. Tamir, A. Haile and T. Dessie. 2009. *Effects of feed restriction on production and reproductive performance of Rhode Island Red pullets*. African Journal of Agricultural Research 4 (7): 642-648.

Tolkamp, B., J. V. Sandilands, and I. Kyriazakis. 2005. *Effects of qualitative feed festriction during rearing on the performance of broiler breeders during rearing and Lay.* Edinburgh EH9 3JG, United Kingdom.

Tottori, J.R. Yamaguchi, Y. Murakawa, M. Sato, K. Uchida and S. Tateyama.1997. The *Use of feed restriction for mortality control of chickens in broiler farms*. Avian Disease 41: 433-437.

Tumova, E., M. Skrivan, V. Skrivanova and L. Kacerovska. 2002. *Effect of early feed restriction on growth in broiler chickens, turkeys and rabbits.* Czech Journal of Animal Science 47: 418-428.

Ukachukwu, S.N. and U.O. Akpan. 2007b. *Influence of level and duration of quantitative feed Restriction on post-restriction egg-laying characteristics and egg quality of pullets.* International Journal of Poultry Science 6: 567 – 572.

Veldkamp, T., R.P. Kwakkel, P.R Ferket, P.C.M. Simons, and J.P.T.M Noordhuizen and A. Pijpers. 2000. *Effects of ambient temperature, arginine to lysine ratio, and electrolyte balance on performance, carcass and blood parameters in commercial male turkeys.* Poultry Science 79: 1608-1616.

Veldkamp, T., P.R Ferket, R.P. Kwakkel, C. Nixey, and J.P.T.M Noordhuizen. 2000. *Interaction between ambient temperature and supplementation of synthetic amino acids on performance and carcass parameters in commercial male turkeys.* Poultry Science 79: 1472-1477.

Veldkemp T., R.P. Kwakkel, P.R. Ferket and M.W. A. Verstegen. 2005. *Growth responses to dietary energy and lysine at high and low ambient temperature in male turkey.* Poultry Science 84: 273-282.

Yalcin, S., P. Settar, S. Ozkan and A. Cahaner. 1997a. *Comparative evaluation of three commercial broiler stocks in hot versus temperate climates*. Poultry Science 76: 921- 929.

Yalcin, S., A. Testik, S. Ozkan, P. Settar, F. Celen and A Cahaner. 1997b. *Performance of naked neck and normal broilers in hot, warm and temperate climates.* Poultry Science 76: 930-937