CHAPTER 1

INTRODUCTION

1.1 Background

Indigenous chickens play a significant role in human nutrition in South Africa (Kingori *et al*., 2007). These indigenous chickens provide meat and eggs for human consumption as well as for economic benefits to rural people of Limpopo province. However, the productivity of indigenous Venda chickens is generally low, implying that their contribution to the alleviation of household protein food security may not be fully realized without appropriate interventions. There is some evidence indicating that poor productivity in chickens may be related to the size of eggs (Alders Spradbrow., 2001; Swatson *et al*., 2001; Rashid *et al*., 2005; Kingori *et al*., 2007). There is evidence that small eggs tend to have low hatchability and chicks from such eggs have higher mortalities (Donald *et al*., 2002). Such information on indigenous chickens is limited and not extensive.

1.2 Problem statement

Hatchability of Venda chicken eggs is low. Survival rate of chicks hatched from indigenous chicken eggs is also low. Similarly, growth rate of indigenous chicks is low (Tadelle and Ogle, 1996). All these tend to have negative effects on the farmers' income and nutrition.

1.3 Motivation

This study will generate information on the effects of egg weight on chick hatch-weight, growth, mortality and carcass characteristics of Venda chickens. Such information will help farmers improve the productivity of their chickens and hence improve their incomes and nutrition.

1.4 Objective

The objective of this study was to determine the effect of egg weight on hatchability, chick hatch-weight, feed intake, digestibility, growth, mortality and carcass characteristics of Venda chickens.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Although there is extensive evidence of the important role that indigenous chickens play in the lives of rural households, not much has been done in terms of improving the productivity of these chickens. It is estimated that indigenous chickens contribute up to 75 % of eggs and meat produced in Africa, and 50 % of eggs produced in South-Asia (Banarjee and Sharma, 1998). Recently, there has been increasing interest in studying indigenous chicken breeds (Gondwe and Wollny, 2005). Improvement in the productivity of indigenous breeds requires attention to nutritional, breeding, health and management aspects. Information on egg weight requirements in indigenous chickens for optimum hatchability is, however, limited.

2.2 Effect of egg weight on hatchability, chick hatch-weight and performance

Effect of egg weight on hatchability is an important economic trait in domestic poultry. It is a function of chicks hatched and is affected by numerous factors, namely, fertility, egg quality, handling of eggs and management conditions during incubation and hatching. Hatchability is one of the perquisites for better propagation of any breed. Farooq *et al.* (2001b) reported 71.16 % hatchability in quails on the basis of fertile eggs. Poor egg shell weight has also been reported to result in higher embryonic mortality influenced by egg weight. Lower hatchability was observed in a flock, if embryonic mortality is higher and fertility is lower (Roque and Soares 1994). Positive association of egg weight with hatching chick weight was also reported by Farooq *et al.* (2001b). Hatching chick weight has been reported to be 62 to 72 % (Wilson, 1991) and 68, 2 % (Murad *et al*. 2001) of the initial egg weight. Egg weight was found to influence hatchability and weight of the day-old chicks (Farooq *et al.*, 2000a. Wilson (1991) and Kalita (1994) reported a higher hatchability for intermediate sized eggs compared to too small or too large eggs. Farooq *et al.* (2001) and Murad *et al.* (2001) also reported significant influence of egg weight on hatching performance in Japanese quails. The authors reported lower hatchability of small sized eggs. Shanaway (1994) reported improvement in hatchability an increase in egg weight of Japanese Quails. Farooq *et al.* (2001b) considered egg and shell weight as the two most important factors affecting hatchability, provided that management is not a limiting factor. Egg weight increases with breeder age, and eggs of different sizes have different physical and chemical qualities that affect hatchability and chick quality. Chick weight at hatching is strongly related to egg weight. Heavier chicks may present higher body development and smaller yolk sacs due to higher development during incubation, or less developed bodies and larger yolk sacs, allowing them to survive longer before exogenous feed is provided (Skewes *et al*., 1988). Egg weight influences the weight of day old chicks (Farooq *et al.,* 2000a). Too large and too small eggs have been reported to cause problems in incubation and adversely affect the hatchability. Kalita (1994) reported higher hatchability for medium eggs (51-55 g) than for small (45-50 g) or large-sized eggs (56-60 g) in Japanese quails. Asuquo and Okon (1993) reported that egg size within the intermediate range of 45-56 g would hatch better than small eggs. Hatchability, chick hatch-weight and subsequent growth performance of chicks are closely related to the weight of the egg. Chicks born excessively small or large eggs exhibit low growth rates (Uluocak *et al.*, 1995).

Furthermore, egg weight and weight of one-day old chicks are highly correlated. In the coturnix quail intermediate to large eggs, i.e. those over 8.5 g (Narahari *et al.*, 1988) or 9 g (Insko *et al.*, 1971) displayed the highest fertility and hatchability. Senapati *et al.* (1996) reported positive correlations between egg weight and hatchability. Some studies have shown that egg size can affect both parental and offspring fitness. Williams (1994) studied the relationship between egg size and offspring quality in birds and came up with equivocal results. The author reported that egg size typically affects hatchling mass more strongly than it affects hatching size in birds because the main effect of egg size lies in the mass of the residual yolk sac that the chick retains at hatching. Gonzalez *et al.* (1999) in a related study suggested the setting of eggs of average weight (medium eggs) in order to achieve good hatchability. The positive correlation observed between egg size and chick hatching weight clearly identified the advantage of initial bigger egg size at the time of setting Gonzalez *et al.* (1999). This observation is in agreement with the findings of Abiola (1999) who reported close correlation between egg and chick hatching weights. Deeming (1994) found that hatchability of ostrich eggs decreased with increasing egg weight.

The modern broiler has been reported to be able to achieve the same body weight in less than a third of the time as compared to their random bred predecessors (Havenstein *et al.,* 2003). However, while the time spent on the farm may be decreasing, the embryo has been found to still require a 21 day incubation period, which translates into a greater percentage of the life of the broiler being spent in the incubator. This places a greater emphasis on the conditions under which this embryonic period of growth occurs. As a result, controlling and optimizing the physical environment that the egg will be exposed to during incubation has become more important.

There are strong positive correlations between pre-incubation egg weight and chick weight and subsequent performance of chickens (Nahm, 2001). The size of newly hatched chicks is directly related to the size of the hatchling egg (Farooq *et al.,* 2001) and there is a progressive increase in egg production related to hatching egg weight. The smaller weight of the newly hatched chick is attributable to smaller egg weight (Khurshid *et al.,* 2004). Quails that were hatched from large eggs laid heavier eggs. Egg quality is another factor affecting hatchability. Egg weight, egg shape, shell weight and thickness are external indicators of egg quality. Farooq *et al*. (2001b) and Murad *et al.* (2001) reported lower hatchability of small sized eggs in quail, based on fertile eggs. A reduced hatchability would be observed if embryonic mortality is higher and fertility is lower (Farooq *et al.*, 2001a).

However, a strong positive correlation between egg weight and hatchling weight, which is constant across species (Wilson, 1991). According to Wilson (1991), the hatchling weight is determined primarily by egg weight and secondarily by weight losses during incubation, gender of chick and time after hatching. Chick weight normally represents 62-76 % of initial egg weight (Tullet and Burton, 1982). The correlation between egg weight and chick weight decreased with age of the chick, and at the end of trial period, no significant correlation was recorded in either breed (Tullet and Burton, 1982).

The effect of egg weight on cumulative feed consumption (Aydi and Bilgehan, 2007) found to be significant. The highest feed consumption was found in the heavy group, and the lowest group was the light group. The effect of egg weight on feed conversion ratio was significant. The effect of chick hatch-weight on the mortality ratio was found to be insignificant (Aydi and Bilgehan, 2007).

2.3 Effect of egg weight on growth of the chickens

Poultry breeds have been artificially selected over many generations for two main economic traits, egg production and growth rate. According to French and Tullet (1991), these two traits are negatively correlated. Selection for increased body weight has been shown to increase egg weight, whereas selection for increased egg production decreases egg weight (French and Tullet, 1991). There is, however, a strong positive correlation between egg weight and hatchling weight, which is constant across species (Wilson, 1991). The phenotypic correlation between chicken egg weight and hatchling weight is generally high, ranging from 0.50 to 0.95 at hatching (Tullet and Burton, 1982; Shanaway, 1987; Yannakopoulos and Tserveni-Gousi, 1987). The correlation between egg weight and body weight between five and eight weeks of age is also significant in many broiler lines, but of a lower magnitude than the correlation between egg weight and hatchling weight (McNaughton *et al.*, 1978). Hearn (1986) suggested that if eggs were segregated by size in the hatchery and the chicks rose separately, the variability at slaughtering age would be reduced and the growth of each group optimized. In a comprehensive literature review on egg weight to chick weight ratios in six poultry species, Shanaway (1987) observed that chick weight increases 0.59g for each 1.0 g of increase in weight of eggs heavier than 1.91 g.

2.4 Nutrient availability at hatching

After the chick emerges from the egg, several changes must take place in order for it to successfully adapt to its new environment. One of the primary changes that must take place will be the shift away from the chick's sole dependence on the lipid rich yolk sac for nutrients to carbohydrate rich exogenous feed sources. Although the newly hatched chick does retain some residual yolk after hatching (Romanoff, 1960), it was not sufficient to support the chick during an extended period of starvation post-hatching (Bigot *et al.*, 2003). Rather, this residual yolk was thought to provide energy and protein immediately following hatching, and then act as a supplement to exogenous feed (Sklan *et al.*, 2000). In the newly hatched chick, the yolk sac was shown to be absorbed directly into the circulation (Lambson, 1970) or transported through the yolk stalk into the small intestines (Noy and Sklan, 2002). When chicks have access to feed, yolk absorption was increased in a manner that occurred mainly via the yolk stalk into the intestines. In order to accommodate the chick's change in nutrient intake, rapid intestinal development also occurred during the immediate post-hatching period with dramatic increases in villi size and volume appearing in the small intestines during the first day after hatching (Geyra *et al.,* 2001; Sklan, 2001). Intestinal growth can occur even if the chicks were unfed, however it did not equal the growth that occurred in chicks with access to feed and the difference remained even after the delayed chicks were given feed (Bigot *et al*., 2003). Intestinal absorption of exogenous proteins and carbohydrates has previously been noted to be low in newly hatched chicks (when compared to lipid absorption) and was shown to increase with age (Sulistiyanto *et al*., 1999). Noy and Sklan (1999) suggested that this initial reduction in hydrophilic compounds was due to the presence of hydrophobic lipid compound from the yolk being present in the intestinal tract.

2.5 Post-hatch nutrition and muscle growth

Several reports have demonstrated that delay in feed intake after hatch adversely affects posthatch performance of chicks, especially growth (Pinchasov and Noy, 1993; Bigot *et al*., 2003; Gonzales *et al*., 2003). However, additional factors may aggravate this effect of delay in feed access. Despite the importance of post-hatch feed access, it may be 48 h before the chicks have access to feed in a commercial setting, due to transportation time to farms (Careghi *et al*., 2005). Not only did this delay impede intestinal development, it also had effects on broiler performance that lasted until market age (Noy and Sklan, 1999; Bigot *et al*., 2003). Chick body weight increased by 2-3 folds during the first week of grow-out (Noy and Sklan, 2002) and it was during this early post-hatch period that the greatest muscle growth occurred (Moss *et al*., 1964). Although skeletal muscle fibers were essentially fully formed at hatching, muscle growth can still occur post-hatch of the muscle fiber via increased DNA content of the fibers. Halevy *et al*. (2000) and Mozdziak *et al.* (2002) observed that if chicks experienced delayed access to feed during the few days post-hatch, satellite cell proliferation could either be enhanced or detrimentally altered. Chicks that were denied feed for one day demonstrated an increase in overall cell number due to satellite cell proliferation. However, this may be attributed to a stress reaction as other studies have also demonstrated an initial increase in cell number and satellite cell activity due to mechanical stress or muscle injury (Bischoff and Heintz, 1994; Grounds, 1998). As the period of starvation increased beyond one day, satellite cell activity dramatically decreased, as did cell number. Furthermore, Halevy *et al*. (2000) also observed that the age of the chick plays a role in how severe the effects of delayed feeding on muscle growth were.

2.5 Conclusion

Information on the effect of egg weight on hatchability, chick hatch-weight, growth, mortality and carcass characteristics of Venda chickens is limiting and not extensive. It is, therefore, important to ascertain the effects of egg weight on the above factors.

CHAPTER 3

MATERIALS AND METHODS

3.1 Study site

This study was conducted at the University of Limpopo, Turfloop campus. The ambient temperatures around the study area range between 20 and 37 ^{0}C during summer and between five and 32 ^{0}C during the winter season. The mean annual rainfall ranges between 446.8 and 468.4 mm.

3.2 Preparation of the houses

The hatchery and experimental houses were thoroughly cleaned with water, and disinfected with Jeyes fluid from NTK Company in Polokwane, South Africa and then left to dry for seven days. The houses were left empty for one week after cleaning to break the life cycle of any disease causing organisms that were not killed by the disinfectant. The incubator and all the equipment such as drinkers, feeders and wire separators were cleaned thoroughly and disinfected. The footbath was thoroughly cleaned and a new disinfectant added daily.

3.3 Acquisition of materials and birds

All the required materials (medicines, vaccines and chemicals) for the experiment were purchased in advance prior to the commencement of the study. A commercial grower diet was purchased from NTK in Polokwane, South Africa. A total of 360 eggs from 30 weeks old Venda hens were collected from the University of Limpopo Experimental Farm to be used in the experiment.

3.4 Experimental design, treatments and procedures

This study was conducted between May and August, 2009. The study determined the effects of egg weight on egg hatchability, chick hatch-weight, growth, mortality and carcass characteristics of Venda chickens. The egg came from hens which were 30 weeks old. The experiment commenced immediately on availability of eggs from the farm. The eggs were classified into four groups on the basis of their weight as indicated below. Eggs were incubated for 21 days. A completely randomized design was used, having four treatments which were replicated five times, resulting in a total of 20 units of 18 eggs per replicate. The four treatments were as follows:

W_{49g} : Less than 49 g eggs weighed immediately after being laid

W_{50-59g} : 50-59 g eggs weighed immediately after being laid

W_{60-69g} : 60-69 g eggs weighed immediately after being laid

W_{70g} : 70 g eggs weighed immediately after being laid

The second part of the study determined the effect of egg weight on productivity of the chicks. The hatched chicks were marked according to the treatment and replicate. The unsexed chicks were reared up to seven weeks of age in the same building. A layer of 10 cm sawdust was used for bedding and a 24-hour lighting program was used during the trial period. One infrared light, one feeding tray and one water drinker were provided per pen of approximately 1.5 m^2. Feed and water were offered *ad libitum.* The grower diet contained 880 g DM/kg, 16.8 MJ energy/kg DM, 200 g crude protein/kg DM, 11.5 g lysine/kg DM feed and 25 g fat/kg DM feed.

The treatments were as follows:

W_{49g} : Unsexed chicks from less than 49 g egg weight, fed a grower diet *ad-libitum*

W_{50-59g} : Unsexed chicks from 50-59 g egg weight, fed a grower diet *ad-libitum*

W_{60-69g} : Unsexed chicks from 60-69 g egg weight, fed a grower diet *ad-libitum*

W_{70g} : Unsexed chicks from more than 70 g egg weight, fed a grower diet *ad-libitum*

The third part of the study determined the effects of egg weight on feed intake, feed conversion ratio, growth rate, mortality rate and carcass characteristics of female Venda chickens aged between eight and 13 weeks. These were the same chicks used in the first part of the study. Only female chicks were used because there were not enough male chicks. A total of 60 female Venda chickens aged seven weeks, weighing 464 ± 2 g, were used for this part of the study. The experiment was terminated when the chickens were 13 weeks old. The chickens were fed a grower diet. There were four treatments, replicated five times with three chickens per replicate, in a completely randomized design. The treatments were as follows:

W_{49g} : Female chicks from less than 49 g egg weight, fed a grower diet *ad-libitum*

$W_{50\text{-}59g}$: Female chicks from 50-59 g egg weight, fed a grower diet *ad-libitum*

$W_{60\text{-}69g}$: Female chicks from 60-69 g egg weight, fed a grower diet *ad-libitum*

W_{70g} : Female chicks from more than 70 g egg weight, fed a grower diet *ad-libitum*

3.5 Data collection

The hatchability percentage was determined in each replicate by dividing the number of hatched eggs by the total number of eggs set and then multiplying by one hundred. An electronic weighing scale was used to weigh the chicks in each replicate within 24 hours after hatching.

Voluntary feed intake was measured by subtracting the difference in weight between the leftovers from that offered per week, and the difference was divided by the total number of birds per pen. Thus, daily feed intake per bird was calculated from these values. The initial live weight were taken when the chicks were a day old and thereafter mean live weight per pen was measured at weekly intervals, by weighing the chickens in each pen and dividing the weight by the total number of birds in the pen. Feed conversion ratio was calculated by dividing the average feed intake by the average weight gain in each pen. This was calculated as the amount of feed consumed divided by the total weight of live chickens plus those of dead or culled chickens minus initial weight of all the chickens in the pen.

Apparent digestibility was carried out when the birds were seven and 13 weeks old. Apparent digestibility was conducted in specially designed metabolic cages having separate watering and feeding troughs. Two birds were randomly selected from each replicate and transferred to metabolic cages for measurement of apparent digestibility. A three day acclimation period was allowed prior to a three-day collection period. Dropping voided by each bird were collected on a daily basis at 10.00 hours. Care was taken to avoid contamination from feathers, scales, debris and feeds. Apparent digestibility (AD) of nutrients was calculated according to McDonald *et al.* (2002) as follows:

$$AD\ (\%) = \frac{\text{(Amount of nutrient ingested – Amount of nutrient excreted)}}{\text{Amount of nutrient ingested}} \times 100$$

Mortalities were recorded as they occurred per pen. At 13 weeks of age all the remaining Venda chickens per pen were weighed on an electronic weighing scale to obtain the live weight and then slaughtered. Thereafter, carcass weights of the chickens were measured. Dressing percentage was calculated by dividing carcass weight by the live weight times a hundred. Breast, thigh, drumstick and fat pad weights were determined. At the end of each slaughtering, meat samples from the breast part of the slaughtered chickens were dried in the oven for 24 hours at a temperature of 105 ºC and later analyzed for nitrogen content.

3.6 Chemical analysis

Dry matter contents of feeds, feed refusals, faeces and meat were determined by drying the samples in the oven for 24 hours at a temperature of 105 ºC. Ash content of the feeds, feed refusals, faeces and meat were analyzed by ashing a sample at 600 ºC in a muffle furnace for 24 hours (AOAC, 2000). Nitrogen content of feeds, feed refusals, faeces and meat were determined by Semi-micro Kjeldahl method (AOAC, 2000). Gross energy values were determined by using a bomb calorimeter (AOAC, 2000).

3.7 Statistical analysis

Effect of egg weight on hatchability, chick hatch-weight, feed intake, digestibility, growth rate, mortality rate and carcass characteristics of Venda chickens were analyzed using the General Linear Model (GLM) procedure of the Statistical Analysis System (SAS, 2008). The means were separated using Duncan’s multiple-range test procedures (Duncan, 1955). The responses in intake, feed conversion ratio, growth rate, live weight and carcass characteristics to egg weight were modeled using the following quadratic equation:

$$Y = a + b_1x + b_2x^2$$

Where Y= optimum feed intake, feed conversion ratio, growth rate, live weight, mortality rate and carcass characteristics; a = intercept; b = coefficients of quadratic equation; x = egg weight and $-b_1/2b_2$ = x value for optimum response. The quadratic model was fitted to the experimental data by means of NLIN procedure of SAS (SAS, 2008). The quadratic model was used because it gave the best fit.

CHAPTER 4

RESULTS

Results of the effect of egg weight on hatchability and chick hatch-weight of indigenous Venda chickens are presented in Table 4.01. The average egg weights for the treatments were ($P<0.05$) different. Heavier eggs had higher ($P<0.05$) hatchability values. Similarly, heavier eggs hatched heavier ($P<0.05$) chicks. Eggs weighing more than 70 g per egg achieved a chick hatch-weight of 33 g while those weighing less than 49 g per egg had a chick hatch-weight of 29 g.

Linear regressions that predict the relationships between egg weight and hatchability and chick hatch-weight of indigenous Venda chicks are presented in Figures 4.01 and 4.02, respectively and Table 4.02. Egg weight was positively and strongly correlated (r^2 =0.729) with egg hatchability. Similarly, egg weight was positively and strongly correlated (r^2 = 0.953) with chick-hatch weight.

Table 4.01 Effect of egg weight (g/egg) on egg hatchability (%) and chick hatch-weight (g/chick) of indigenous Venda chickens

	Variable		
Treatment	Average egg weight	Hatchability	Hatch-weight
$W_{<49g}$	49^d	28.1^d	29.0^d
W_{50-59g}	59^c	45.5^c	31.0^c
W_{60-69g}	69^b	48.3^b	32.0^b
$W_{>70g}$	70^a	73.9^a	33.0^a
SE	0.10	0.01	0.02

$^{a, b, c, d}$: Means with different superscripts within a column are significantly different ($P<0.05$)

SE : Standard error

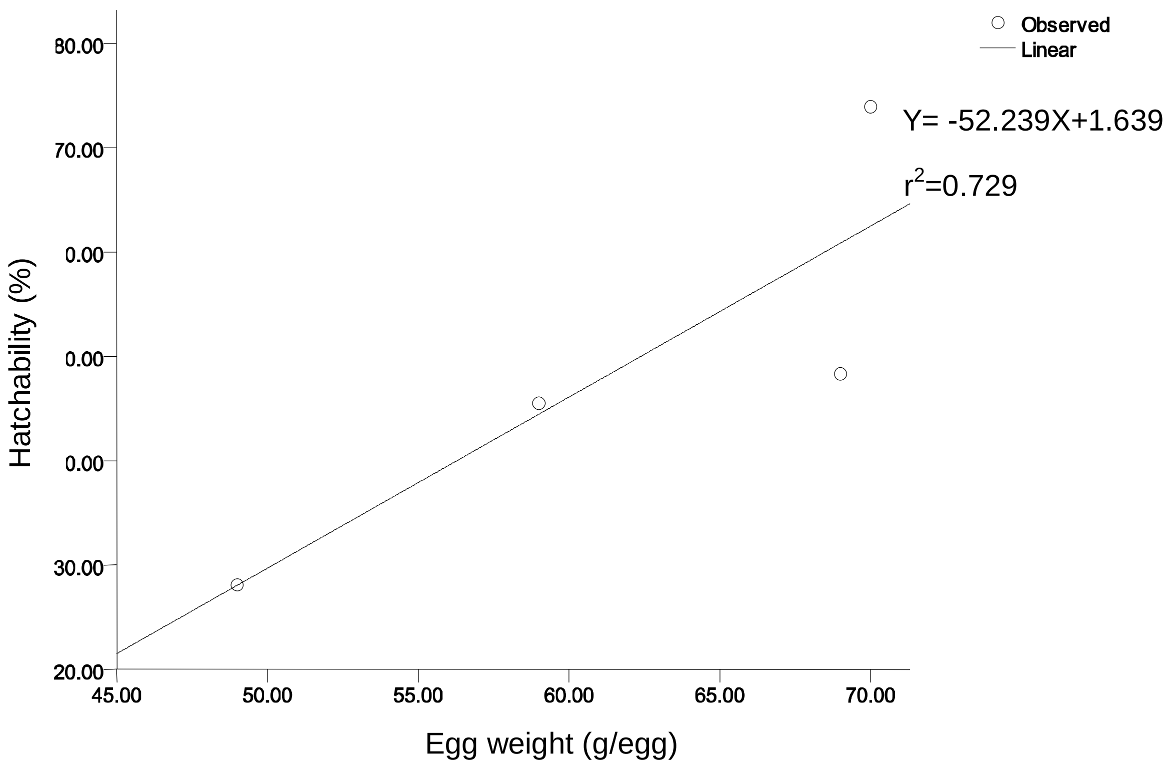

Figure 4.01 Relationship between Venda chicken egg weight and egg hatchability

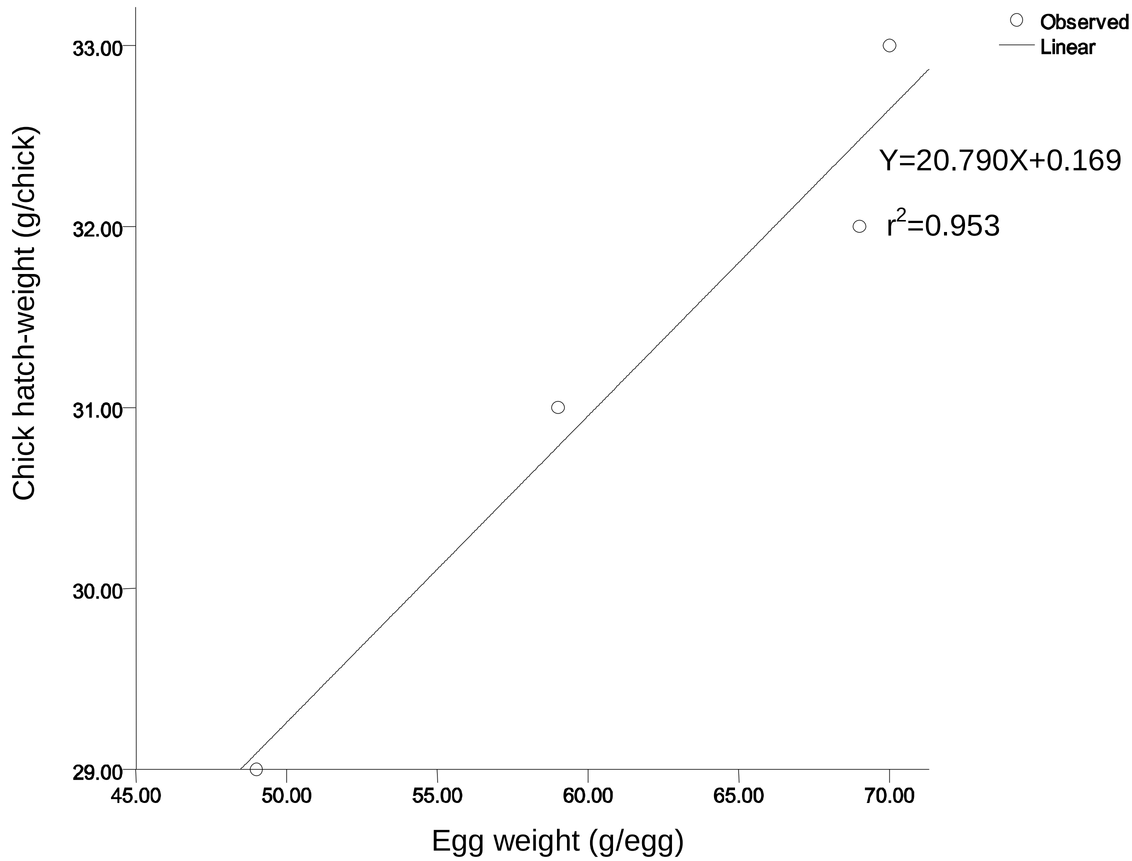

Figure 4.02 Relationship between Venda chicken egg weight and chick hatch-weight

Table 4.02 Relationships between Venda chicken egg weight (g/egg) and egg hatchability (%) and chick hatch-weight (g/chick)

Variable	Formula	r^2	Significance
Hatchability	Y=-52.239X + 1.639	0.729	0.146
Hatch-weight	Y=20.790X + 0.169	0.953	0.024

r^2: Correlation coefficient.

The results of the effect of egg weight on feed intake, growth rate, feed conversion ratio, live weight, mortality, apparent metabolisable energy and nitrogen retention of Venda chicks from day old up to 49 days old are presented in Table 4.03. Venda chicken egg weight had (P<0.05) effects on feed intake, growth rates, live weight, mortality rates except apparent metabolisable energy and nitrogen retention of the chicks. Chicks hatched from eggs weighing less than 49 g ($W_{<49g}$) ate more (P<0.05) feed than those hatched from eggs weighing between 50 and 59 g ($W_{50\text{-}59g}$), 60 and 69 g ($W_{60\text{-}69g}$) and those weighing 70 g and above ($W_{>70g}$). Similarly, chicks hatched from eggs weighing between 50 and 59 g ($W_{50\text{-}59g}$) and between 60 and 69 g ($W_{60\text{-}69g}$) ate more (P<0.05) feed than those hatched from eggs weighing 70 g and above ($W_{>70g}$). However, chicks hatched from eggs weighing between 50 and 59 g ($W_{50\text{-}59g}$) had similar (P>0.05) feed intakes with those hatched from eggs weighing between 60 and 69 g ($W_{60\text{-}69g}$). Chicks hatched from eggs weighing less than 49 g ($W_{<49g}$), between 50 and 59 g ($W_{50\text{-}59g}$) and those from eggs weighing above 70 g ($W_{>70g}$) had similar (P>0.05) growth rates. However, chicks hatched from eggs weighing between 50 and 59 g ($W_{50\text{-}59g}$) grew faster (P<0.05) than those from eggs weighing between 60 and 69 g. Chicks hatched from eggs weighing more than 70 g ($W_{>70g}$) had a better (P<0.05) feed conversion ratio than those hatched from eggs weighing less than 70 g ($W_{60\text{-}69g}$, $W_{50\text{-}59}$ and $W_{<49g}$). Chicks hatched from eggs weighing between 50 and 59 g ($W_{50\text{-}59g}$) weighed more (P<0.05) than those from eggs weighing less than 49 g ($W_{<49g}$) and those hatched from eggs weighing between 60 and 69 g ($W_{60\text{-}69g}$). However, chicks hatched from eggs weighing less than 49 g ($W_{<49g}$), between 60 and 69 g ($W_{60\text{-}69g}$) and those hatched from eggs weighing 70 g and above ($W_{>70g}$)

had similar ($P>0.05$) live weights at 49 days of age. Chicks hatched from eggs weighing less than 49 g ($W_{<49g}$) had the lowest ($P<0.05$) mortality rates as compared to the rest of the treatments. Chicks hatched from eggs weighing between 50 and 59 g (W_{50-59g}) had lower ($P<0.05$) mortality rates than those hatched from eggs weighing between 60 and 69 g (W_{60-69g}) and those hatched from eggs weighing more than 70 g and above ($W_{>70g}$). Egg weight had no ($P>0.05$) effect on metabolisable energy and nitrogen retention of unsexed Venda chickens at seven weeks of age (Table 4.03).

A strong and positive correlation ($r^2 = 0.943$) was observed between Venda chicken egg weight and subsequent chick mortality rates (Figure 4.03 and Table 4.04). However, a slightly poor relationship ($r^2 = 0.584$) was observed between egg weight and subsequent feed conversion ratio of chicks (Figures 4.04 and Table 4.04). Similarly, a poor but positive relationship ($r^2 = 0.691$) was observed between egg weight and subsequent feed intake of the chicks aged between one and seven weeks of age (Figure 4.05 and Table 4.04). Growth rate and live weight of the chicks were optimized at Venda chicken egg weights of 56 and 60 g, respectively (Figures 4.06 and 4.07, respectively and Table 4.05).

Table 4.03 Effect of Venda chicken egg weight on dry matter intake (g/bird/day), growth rate (g/bird/day), feed conversion ratio (FCR) (g DM feed/g weight gain), live weight (g/bird at 49 days old) and mortality of chicks from a day old up to 49 days of age

	Treatments				
Variable	$W_{<49g}$	W_{50-59g}	W_{60-69g}	$W_{>70g}$	SE
Intake	57.4[a]	49.0[b]	48.0[b]	34.0[c]	1.58
Growth rate	6.6[ab]	6.7[a]	6.3[b]	6.5[ab]	0.11
FCR	8.7[a]	7.3[b]	7.6[b]	5.2[c]	0.28
Live weight	470.6[b]	582.0[a]	480.6[b]	507.2[ab]	26.02
Mortality	0.0[d]	2.5[c]	8.9[a]	7.7[ab]	2.47
AME	12.23	13.35	11.58	12.75	0.870
N-retention	1.05	1.55	1.28	1.53	0.24

[a, b, c, d] : Means with different superscripts within a row are significantly different (P<0.05)

SE : Standard error

FCR : Feed conversion ratio

AME : Apparent metabolisable energy

N-retention: Nitrogen retention

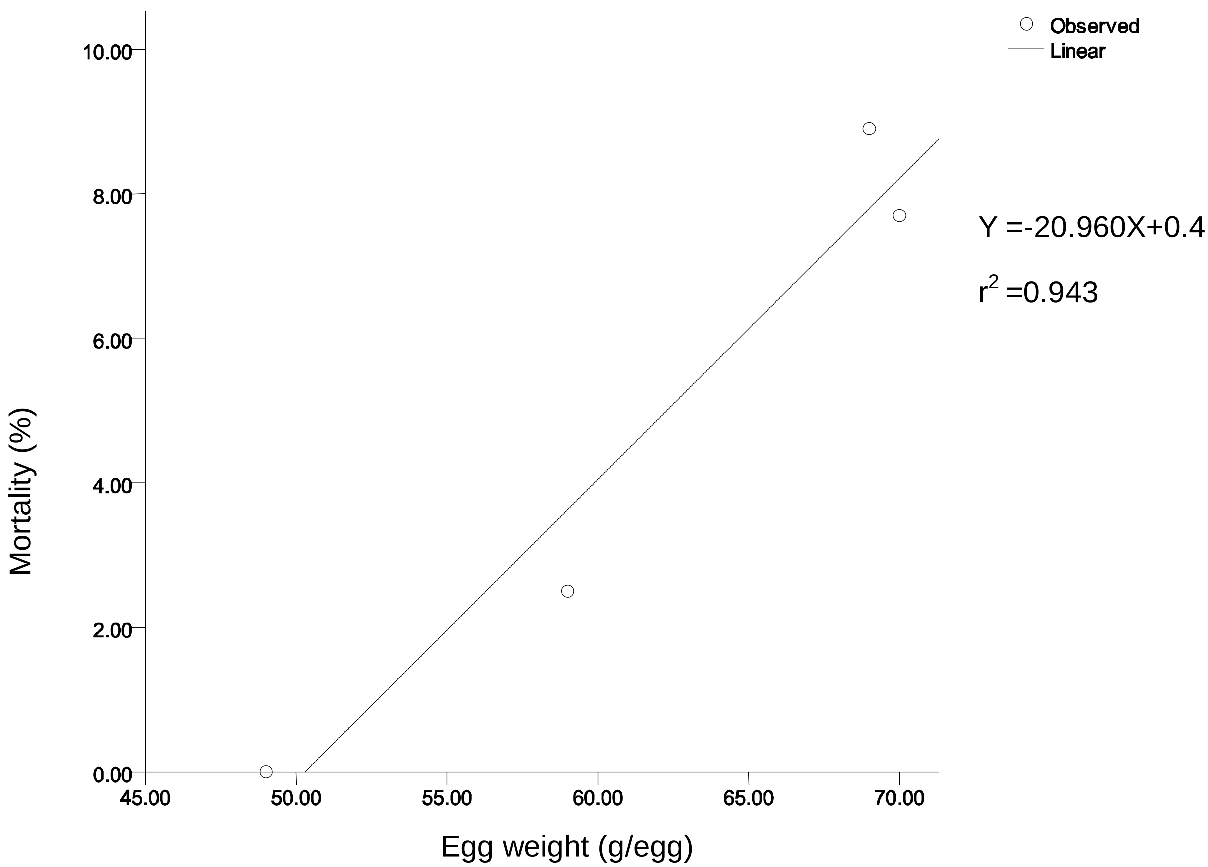

Figure 4.03 Relationship between Venda chicken egg weight and subsequent mortality of the chicks from a day old up to 49 days of age

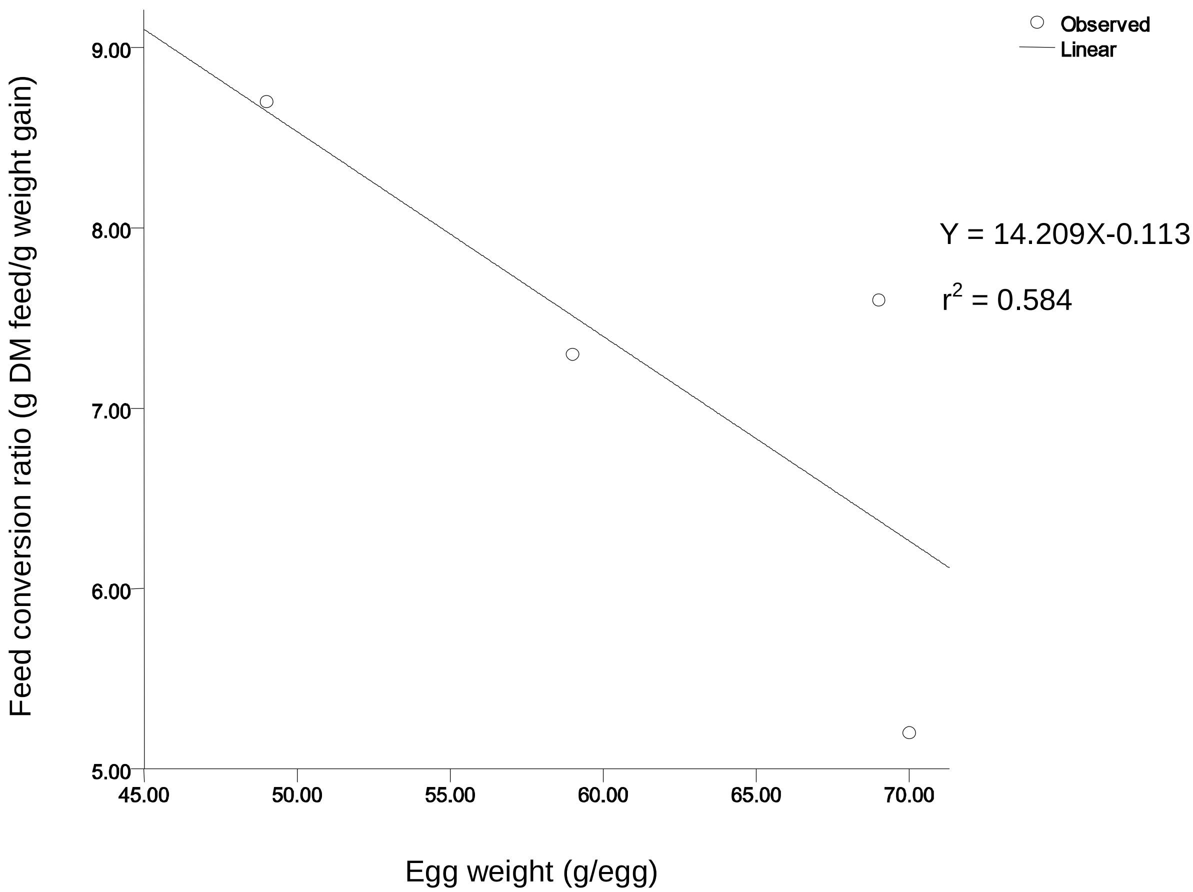

Figure 4.04 Relationship between Venda chicken egg weight and subsequent feed conversion ratio of the chicks from a day old up to 49 days of age

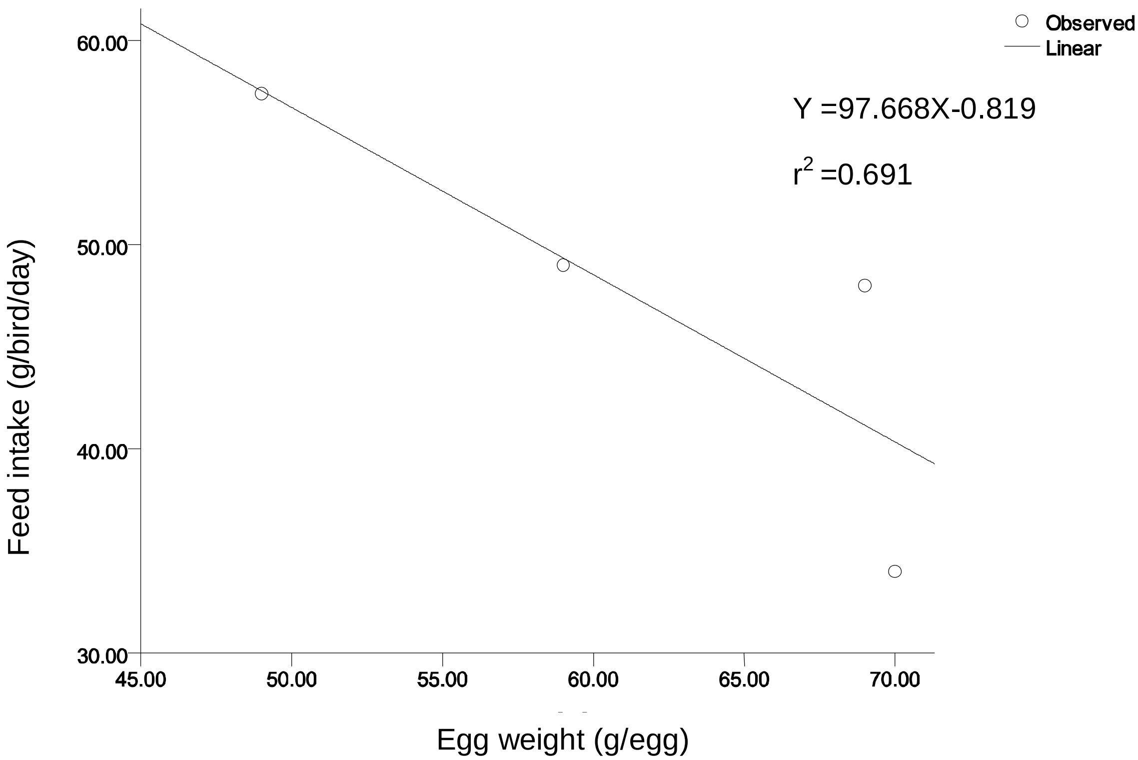

Figure 4.05 Relationship between Venda chicken egg weight and subsequent feed intake of the chicks from a day old up to 49 days of age

Table 4.04 Relationships between Venda chicken egg weight (g/egg) and subsequent feed intake (g/kg), feed conversion ratio (FCR) (g DM feed/g weight gain) and mortality of the chicks between one and seven weeks of age

Variable	Formula	r^2	Significance
Intake	Y = 97.668X-0.819	0.691	0.169
FCR	Y=14.209X-0.113	0.584	0.236
Mortality	Y =-20.960X+0.417	0.943	0.290

r^2: Correlation coefficient.

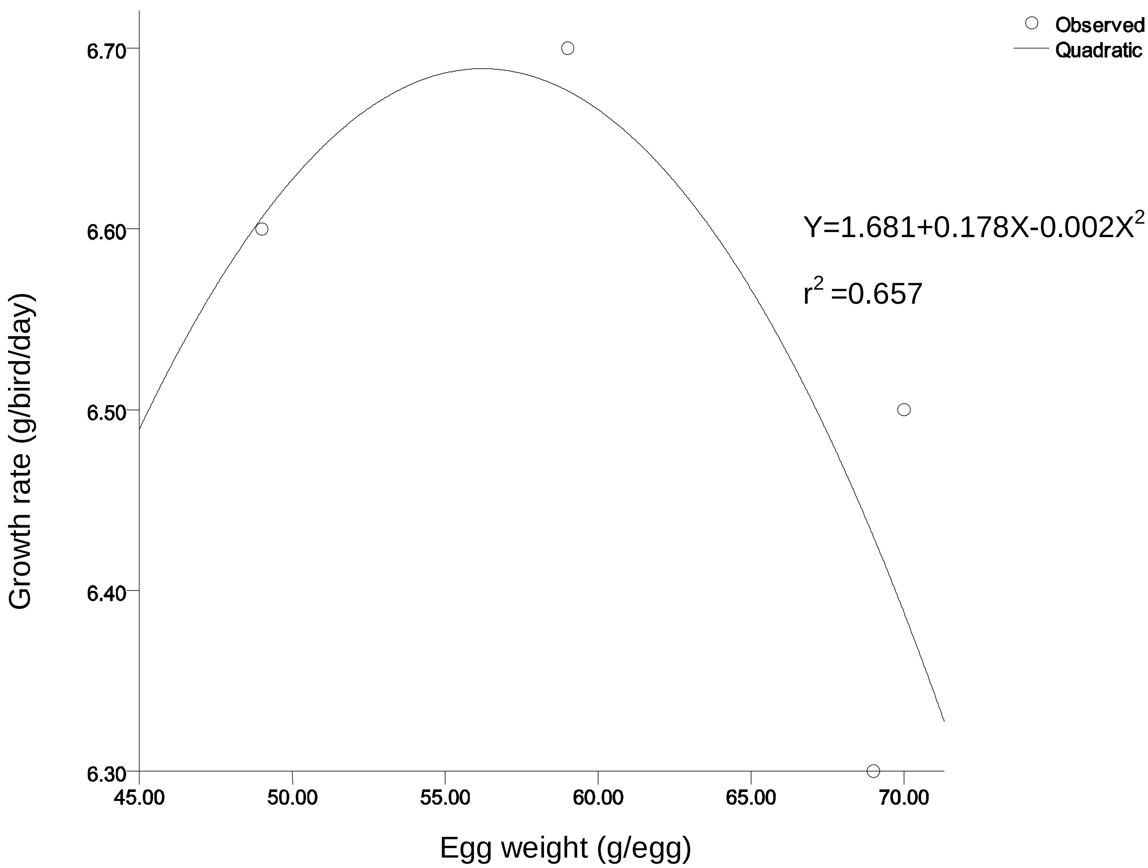

Figure 4.06 Effect of Venda chicken egg weight on subsequent growth of the chicks from a day old up to 49 days of age

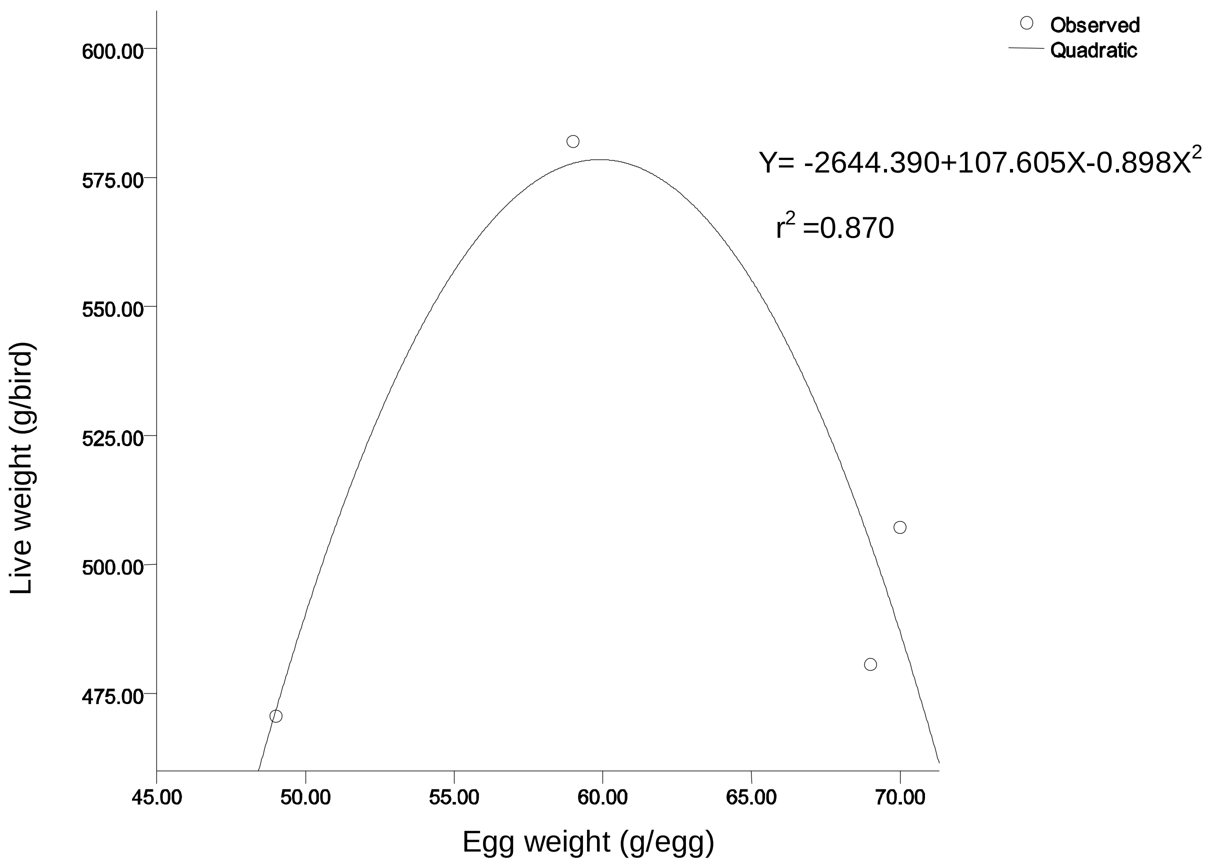

Figure 4.07 Effect of Venda chicken egg weight on subsequent live weight of the chicks at 49 days of age

Table 4.05 Venda chicken egg weight (g/egg) for subsequent optimal growth rate (g/bird/day) and live weight (g/bird) of the chicks between one and seven weeks old

Variable	Formula	r^2	Egg weight	Optimal Y level
Growth rate	$Y = 1.681 + 0.178X - 0.002X^2$	0.657	56	6.7
Live weight	$Y = -2644.390 + 107.605X - .898X^2$	0.870	60	579.1

r^2: Regression coefficient

X: Egg weight

Results of the effect of egg weight on dry matter intake, growth rate and feed conversion ratio, live weight, fat pad weight, nitrogen retention and metabolisable energy of female chickens aged between eight and 13 weeks old are presented in Table 4.06. Female chickens hatched from eggs weighing between 60 and 69 g ($W_{60\text{-}69g}$) ate more ($P<0.05$) feed than those hatched from eggs weighing less than 49 g ($W_{<49g}$), between 50 and 59 g ($W_{50\text{-}59g}$) and 70 g and above ($W_{>70g}$). However, female chickens hatched from eggs weighing between 50 and 59 g ($W_{50\text{-}59g}$) had similar ($P>0.05$) feed intakes as those hatched from eggs weighing 70 g and above ($W_{>70g}$). Venda chicks hatched from eggs weighing less than 49 g ($W_{<49g}$), between 50 and 59 g ($W_{50\text{-}59g}$) and 70 g and above ($W_{>70g}$) had similar ($P>0.05$) growth rates. Similarly, Venda chicks hatched from eggs weighing less than 49 g ($W_{<49g}$), between 60 and 69 ($W_{60\text{-}69g}$) and 70 g and above ($W_{>70g}$) had the same ($P>0.05$) growth rates. However, chicks hatched from eggs weighing between 50 and 59 g ($W_{50\text{-}59g}$) had higher ($P<0.05$) growth rates than those hatched from eggs weighing between 60 and 69 ($W_{60\text{-}69g}$). Venda egg weight had no ($P<0.05$) effect on feed conversion ratio, live weight, apparent metabolisable energy and nitrogen retention of chicks at 13 weeks old. Chicks hatched from eggs weighing less than 49 g ($W_{<49g}$), between 50 and 59 g ($W_{50\text{-}59g}$) and 70 g and above ($W_{>70g}$) had similar ($P>0.05$) fat pad weights. However, chicks hatched from eggs weighing between 60 and 69 g ($W_{60\text{-}69g}$) had higher fat pad weights than those hatched from eggs weighing less than 49 g ($W_{<49g}$), between 50 and 59 g ($W_{50\text{-}59g}$) and 70 g and above ($W_{>70g}$). There were no deaths recorded for Venda chickens aged between eight and thirteen weeks old.

Feed intake, growth rate, feed conversion ratio, live weight and fat pad weight, of the chickens were optimized at different chicken egg weights of 65, 61, 58, 60 and 64 g, respectively (Figures 4.08 to 4.12, respectively and Table 4.07). Optimum feed conversion ratio and fat pad weight were not effectively predicted from Venda chicken egg weight because of a low regression coefficient value.

Table 4.06 Effect of Venda chicken egg weight on subsequent intake (g/bird/day), growth rate (g/bird/day), feed conversion ratio (g DM feed g/weight gain), fat pad (g) weight, nitrogen retention (g/bird/day), apparent metabolisable energy (AME) (MJ/kg/DM) and live weight (g/bird/day) of female chicks from eight weeks old up to 13 weeks of age

	Treatments				
Variable	$W_{<49g}$	W_{50-59g}	W_{60-69g}	$W_{>70g}$	SE
Intake	85.0^{b}	98.3^{ab}	106.9^{a}	93.8^{ab}	5.56
Growth rate	1.8^{ab}	2.1^{a}	1.7^{b}	2.0^{ab}	0.12
FCR	5.0	4.9	6.7	4.8	0.68
Live weight	1084.8	1191.8	1144.4	1102.0	55.45
Fat pad	6.1^{b}	17.2^{b}	30.1^{a}	7.4^{b}	4.29
AME	11.75	12.02	11.90	11.74	0.707
N-retention	0.59	0.63	0.78	0.41	0.251

$^{a, b}$: Means with different superscripts within a row are significantly different (P<0.05)

SE : Standard error

FCR : Feed conversion ratio

AME : Apparent metabolisable energy

N-retention: Nitrogen retention

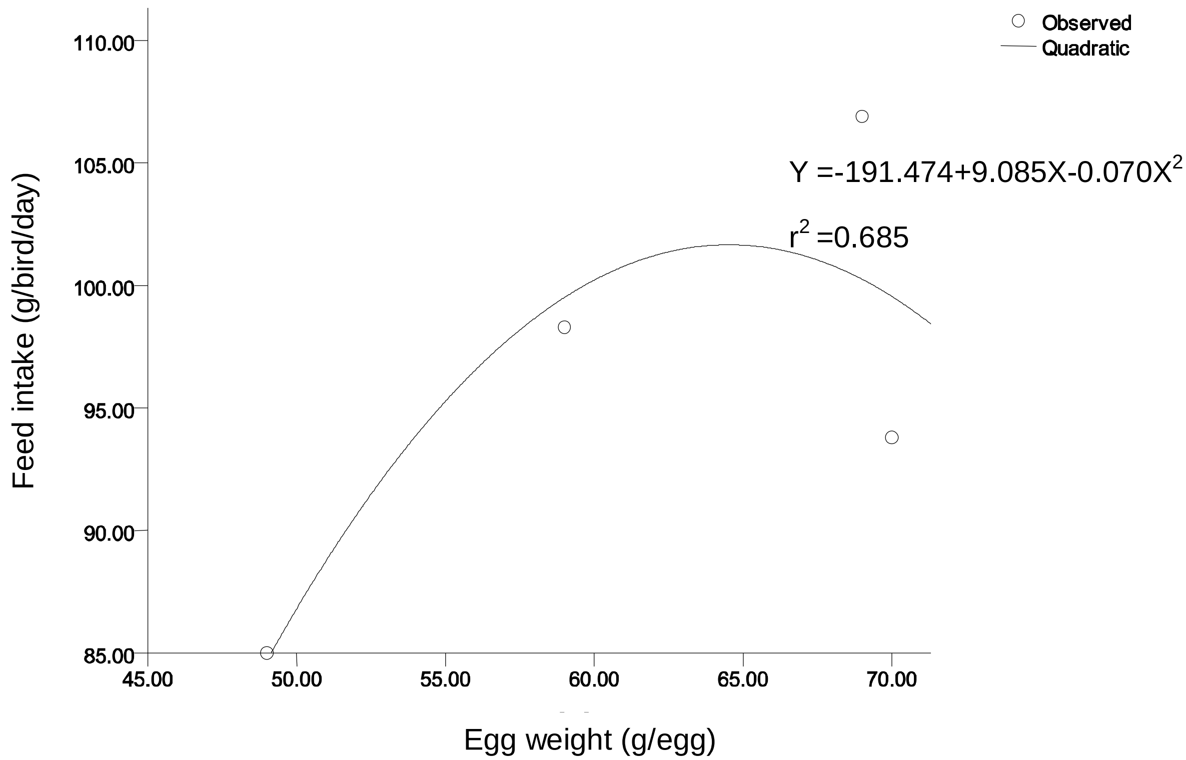

Figure 4.08 Effect of Venda chicken egg weight on subsequent feed intake of female chicks from eight up to 13 weeks of age

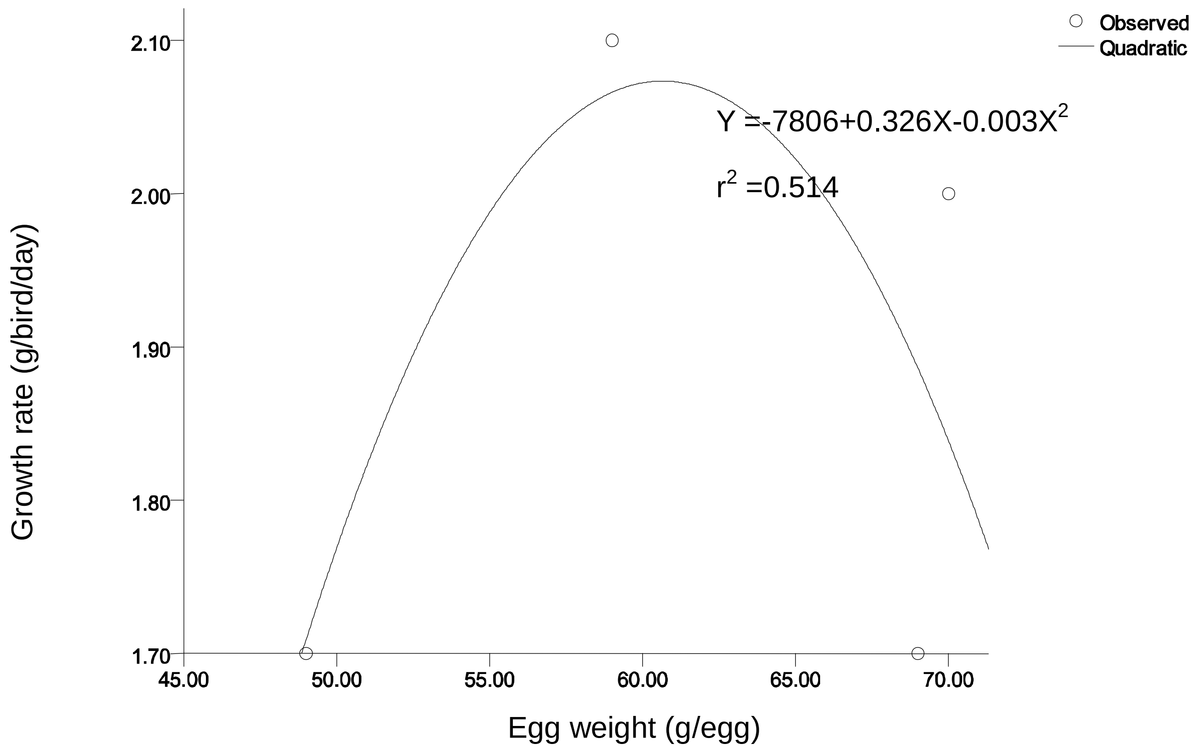

Figure 4.09 Effect of Venda chicken egg weight on subsequent growth rate of female chicks from eight up to 13 weeks of age

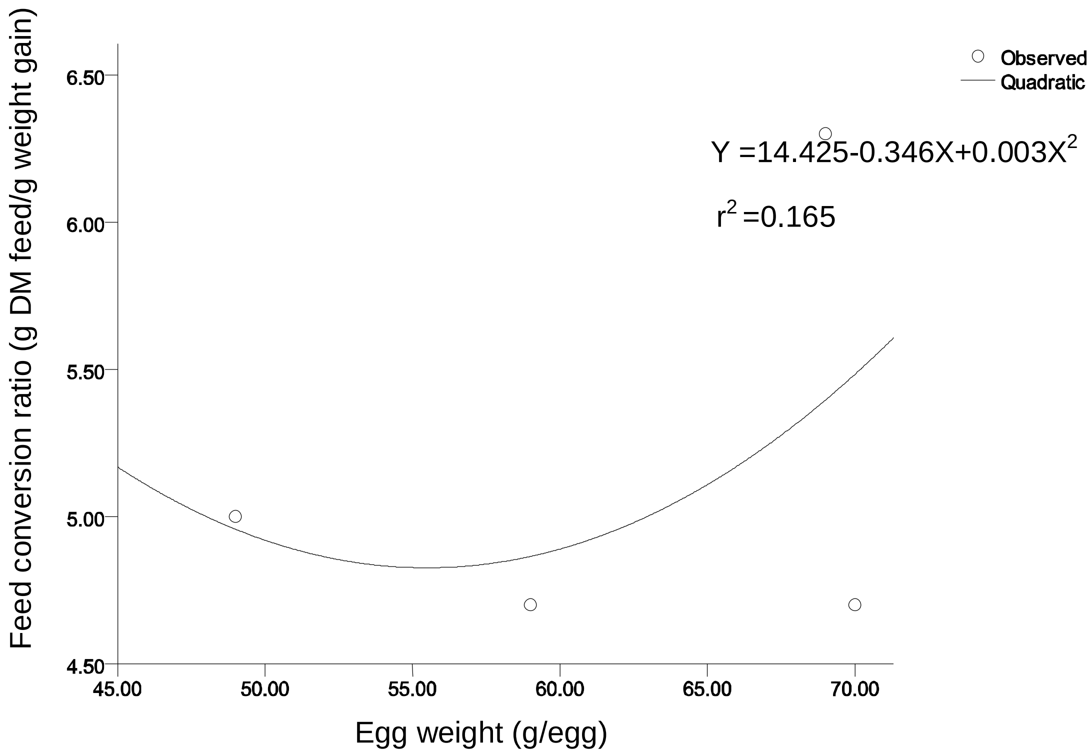

Figure 4.10 Effect of Venda chicken egg weight on feed conversion ratio of female chicks from eight up to 13 weeks of age

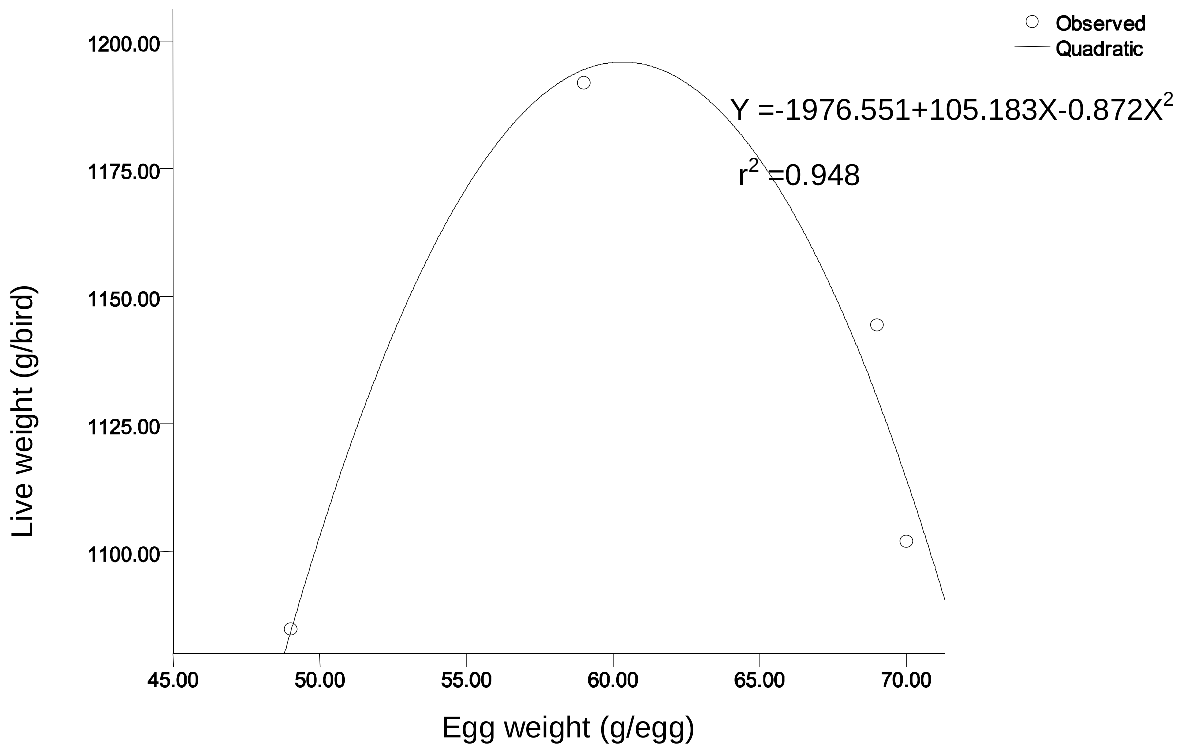

Figure 4.11 Effect of Venda chicken egg weight on subsequent live weight of female chicks at 91days of age

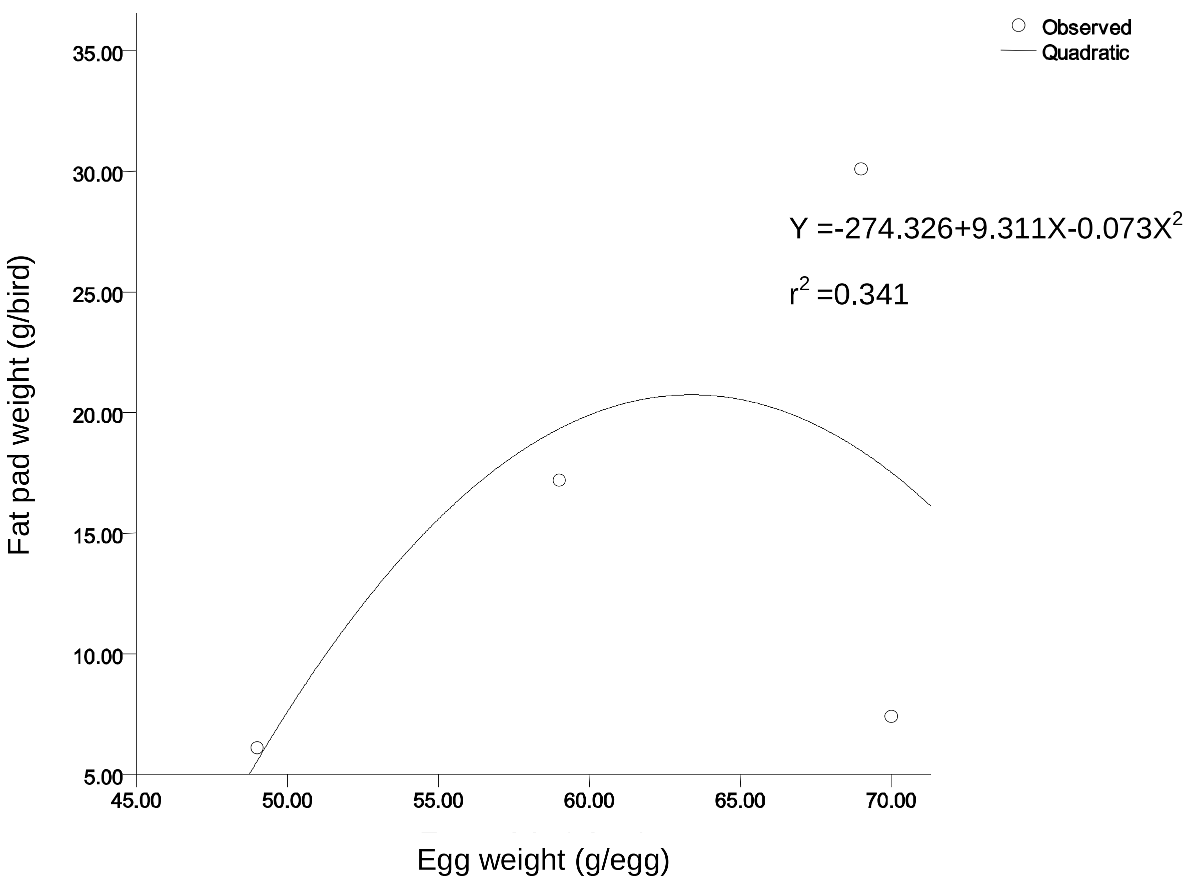

Figure 4.12 Effect of Venda chicken egg weight on subsequent fat pad weight of female chicks at 13 weeks of age

Table 4.07 Effect of Venda chicken egg weight (g/egg) on subsequent optimal feed intake (g/bird/day), growth (g/bird/day) and feed conversion ratio (g DM feed/g weight gain), live weight (g/bird) and fat pad weight (g) of female chicks between eight and 13 weeks of age

Variable	Formula	r^2	Egg weight	Optimal Y level
Intake	$Y = -191.474 + 9.085X - 0.070X^2$	0.685	65	103.3
Growth rate	$Y = -7806 + 0.326X - 0.003X^2$	0.514	61	2.1
FCR	$Y = 180.845 - 4.341X + 0.035X^2$	0.121	58	4.4
Live weight	$Y = -1976.551 + 105.183X - 0.872X^2$	0.948	60	1195
Fat pad	$Y = -274.326 + 9.311X - 0.073X^2$	0.341	64	22.7

r^2: Regression coefficient

X: Egg weight

Results of the effect of egg weight on live weight, carcass, breast meat, thigh, drumstick, fat pad weights and nitrogen content of the breast meat samples of female chickens at 13 weeks of age are presented in Table 4.08. Venda chicken egg weight had no (P>0.05) effect on live weight, carcass, breast meat, thigh and drumstick weights except nitrogen content of breast meat samples of female chicks at 91 days old. However, female chickens hatched from eggs weighing less than 49 g ($W_{<49g}$) and between 60 and 69 g (W_{60-69g}) had similar (P>0.05) fat pad weights. Similarly, female chicks hatched from eggs weighing between 50 and 59 g (W_{50-59g}) and those hatched from eggs weighing above 70 g ($W_{>70g}$) had similar (P>0.05) fat pad weights at thirteen weeks of age.

Table 4.08 Effect of Venda chicken egg weight on subsequent live weight (g/bird/day), carcass weight (g/bird), carcass parts (g) and nitrogen content of the breast meat samples of the female chickens at 13 weeks of age

	Treatments				
Variable	$W_{<49g}$	W_{50-59g}	W_{60-69g}	$W_{>70g}$	SE
Live weight	1116	1002	1110	1058	61.164
Carcass weight	818	723	794	823	51.92
Breast yield	195	188	199	210	13.28
Thighs	131.2	114.2	124.6	126.6	8.72
Drum stick	114	94	109	113	7.88
Nitrogen	14.0^{a}	13.3^{c}	13.6^{b}	13.4^{c}	0.053

^{a,b,c,d}: Means with different superscripts within a row are significantly different ($P<0.05$)

SE : Standard error

CHAPTER 5

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

The results of this study indicate that weight of Venda chicken eggs had an effect on egg hatchability. Heavier eggs had higher hatchability values. As a result, egg weight was positively and strongly correlated (r^2 = 0.729) with egg hatchability. This is similar to the findings of Constantini and Panella (1984) in broiler chickens. Yannakopoulos and Tserveni-Gousi (1986) also found similar results in Japanese quails. However, Gonzalez *et al.* (1999) and Abiola *et al.* (2008) found contrary results. These authors found that broiler chicken eggs of medium weight are more suitable for setting in order to obtain higher hatchability. Farooq *et al.* (2001) and Narkhede *et al*. (1981) found negative correlations between egg weight and hatchability in crossbred chickens. As indicated, in their studies heavier eggs resulted in lower hatchability. However, no similar studies on Venda eggs were found**.**

Chicks with higher hatch-weight came from heavier eggs. As a result, egg weight was positively and strongly correlated (r^2 = 0.953) with chick hatch-weight. Heavier eggs contain more nutrients than small eggs (Williams, 1994). As a result, developing embryos from heavier eggs tend to have more nutrients for their growth requirements. Similarly, chicks from heavier eggs tend to have more yolk attachment at hatching (Birkhead and Nettleship, 1982; Hassane *et al*., 2005; Wolanski *et al.,* 2006). Chicks tend to depend on this yolk during the first few hours after hatching (Deeming, 1989). The yolk attachment is utilized by the chicks after hatching and the potential performance of day-old chicks may depend on the quality and quantity of this yolk. The present findings are similar to those of Gonzalez *et al*. (1999) who observed that chicks from heavier ostrich eggs had a higher hatch-weight than those from lighter eggs. Narkhede *et al.* (1981) reported a strong and positive correlation (r^2 = 0.93) between egg weight and chick hatch-weight in crossbred chickens (Rhode Island Red X White Leghorn). Tona *et al. (*2002) observed similar findings in broiler chickens. However, contrary results were found by Asuquo and Okon (1993) which indicated that egg size within the intermediate weight range of 45 to 56 g hatched heavier chicks than small or large eggs.

Chicks hatched from heavier eggs ate less than those hatched from lighter eggs. As indicated, there was a negative relationship between egg weight and feed intake in Venda chicks aged between one and seven weeks. These results are similar to those of Petek *et al* (2003) in quails aged 17 weeks. However, Vieira and Moran (1998) found no differences in intake due to differences in broiler chicken egg weight.

Egg weights of Venda chickens had effects of growth rates of the chicks. Chicks hatched from heavier eggs tended to have an advantage in early weight gains, however, this difference diminished with age. This may be explained in terms of higher intakes in chicks hatched from lighter eggs. However, from quadratic analysis egg weight of 56 g was calculated for optimal growth. Vieira and Moran (1998) found similar results in broiler chickens. However, Skewes (1988) found higher live weight gains in chickens hatched from heavier quail eggs.

In the present study there was a negative correlation (r^2 = 0.584) between egg weight and feed conversion ratio. Thus, heavier eggs hatched chicks with better (lower) feed conversion ratios. This is similar to the findings of Petek *et al*. (2003) in quails. However, De Witt and Schwalbach (2004) found that feed conversion ratio was better in chicks hatched from medium New Hampshire and Rhode Island Red eggs than those hatched from larger eggs.

Egg weight had significant effect on live weight of the chickens at seven weeks. Chicks hatched from heavier eggs tended to have higher live weight than those hatched from lighter eggs. However, quadratic analysis indicated that an egg weight of 60 g optimized (r^2 = 0.870) the live weight of the chickens at seven weeks old. This optimization may be explained in terms of higher intakes and growth rates of these chicks. Similar results were observed by Pearson and Herron (1981) in broiler chicks.

Growth rate and live weight of the chicks were optimized at different Venda chicken egg weights of 56 and 60 g, respectively. This has implications in selecting eggs for incubation. As a result, heavier eggs may be required for optimizing live weight than that required for optimizing growth rate at seven weeks of age. Hearn (1986) and Shanaway (1987) made similar observations.

Chick mortality between one and seven weeks of age was affected by egg weight. Thus, a strong and positive relationship (r^2 =0.943) was observed between egg weight and mortality of chicks aged between one and seven weeks. This meant that heavier eggs tended to hatch chicks which had higher mortality rates. The biological explanations for this are not clear (McNaughton *et al*., 1978). These results are similar to those of Petek *et al*. (2003) and Vieira and Moran (1996) in broiler chickens and quails, respectively.

Egg weight did not affect metabolisable energy and nitrogen retention of the chickens. This may be explained by the fact that the chickens had similar diets (Okitoi *et al*., 2006). Similar results were observed by Cowan and Michie (1978) and Vieira and Moran (1998) in broiler chickens.

Venda egg weight had effect on intake of the chickens aged between eight and thirteen weeks. Venda chickens hatched from heavier eggs ate more than those hatched from lighter eggs. However, quadratic analysis (r^2 = 0.685) indicated an egg weight of 65 g for optimal intake. Cowan and Michie (1978) also observed that broiler chicks hatched from heavier eggs had higher intakes.

Egg weight did not affect growth rate and feed conversion ratio of Venda chickens aged between eight and thirteen weeks. However, quadratic analysis indicated that growth rate and feed conversion ratio were optimized at different egg weights of 61 (r^2 = 0.514) and 58 g. (r^2 = 0.121), respectively. Vieira and Moran (1998) observed similar results in broiler chickens. However, Petek *et al*. (2003) found that older broiler chickens hatched from heavier eggs had higher growth rates. These authors explained their results in terms of higher intakes.

Venda chicken egg weight had no effect on metabolisable energy and nitrogen retention of the chickens aged thirteen weeks. This may be explained by the fact that the chickens had similar dietary intake.

Egg weight did not have an effect on live weight, carcass weight and carcass parts of Venda chickens aged thirteen weeks except fat pad weight. Similarities in the above variables may be due to similarities in growth rates, feed conversion ratios, metabolisable energy and nitrogen retention of the chickens. These findings are contrary to those of Vieira and Moran (1998) who found that higher carcass weights were obtained from chickens hatched from heavier than lighter eggs. In the present study, Venda chickens hatched from lighter eggs had lower fat pad weights than those hatched from heavier eggs. However, Vieira and Moran (1998) found that egg weight did not affect fat pad weights of broiler chickens at 6 weeks old.

Egg weight affected nitrogen content of breast meat of Venda chickens at thirteen weeks old. As a result, meat samples of chickens hatched from lighter eggs had higher nitrogen contents. These results cannot be explained by similarities in nitrogen retentions between the treatments. Abiola *et al.* (2008) found similar results. However, Vieira and Moran (1998) found that egg weight did not affect nitrogen content of breast meat of broiler chickens at 6 weeks old.

5.02 Conclusions

Weight of Venda chicken eggs is a critical factor to be considered during the incubation process as it affects egg hatchability and chick hatch-weight. Heavier eggs resulted in higher hatchability and chick hatch-weight as compared to smaller eggs. Egg size affected both live weight and growth rates of the chickens. Optimal growth rates and live weight would be obtained from eggs weighing 56 and 60 g, respectively. Egg weight affected chicken live weight at seven weeks old. As a result, chicks hatched from heavier eggs tended to have higher live weight than those hatched from lighter eggs. Heavier eggs hatched chicks which had higher mortality rates. There was no clear biological explanation for this.

5.03 Recommendations

More studies should be done to determine why large-sized eggs hatch heavier chicks than mediun or lighter eggs. There is need to determine biological reasons for this. Similarly, there is need to determine biological reasons for higher mortality values in chicks hatched from heavier eggs than in those hatched from lighter eggs.

CHAPTER 6

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