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Effect of Egg Weight on Physical Egg Parameters and Hatchability of Indigenous Venda Chickens

O.J. Alabi, J.W. Ng'ambi and D. Norris
Department of Agricultural Economics and Animal ProductionUniversity of LimpopoPrivate Bag X1106. Sovenga, 0727, South Africa

Corresponding Author: O.J. Alabi, Department of Agricultural Economics and Animal Production, University of Limpopo, Private Bag X1106, Sovenga 0727, South Africa Tel: +2715 268 4618, +277 3424 4389

ABSTRACT
Egg weight is an important parameter that influences hatchability. This study was conducted to determine the effect of egg weight on egg weight loss, fertility, embryonic mortality, hatching yield and hatchability of indigenous Venda chickens (*Gallus gallusdomesticus*). A total of 690 Venda chicken eggs obtained from the Agricultural Research Council, Pretoria, South Africa were classified according to three weight groups (A:>50 g, B: 45-50 g and C:<45 g). A complete randomized design of three Treatments, five replicates and each replicate having 46 eggs was used for the experiment. Egg weight loss, embryonic mortalities (total, early, medium and late), hatching yield and hatchability were significantly (p<0.001) affected. However, no differences were detected in the fertility of total egg and egg fertility rate. The medium size eggs (group B) had the least mortality (18.11%), the highest hatching yield (76.39%) and hatchability (81.89%). This may imply that sorting indigenous Venda chickens' eggs prior to incubation might be advantageous in production operation aimed at improving the productivity of these chickens.

Key words: Eggs physical parameters, embryonic deaths, hatching yield, hatchability, hatch-weight

INTRODUCTION
Poultry accounts for more than 30% of all animal protein consumption worldwide (Permin and Pedersen, 2000). Poultry will account for 40% of the global increase in demand for meat in 2020, far higher than the 28% it accounted for in 1997, reflecting a dramatic shift in taste from red meat to chicken (Rosegrant *et al.*, 2001). This value is expected to be higher in rural areas where indigenous chickens account for more than 80% of poultry production (GuEye, 1998).

Indigenous chickens are economically, nutritionally and culturally important in many countries. They are mainly kept for meat and eggs, they are also sold when cash is needed in the household (Ekue *et al.*, 2002). Other merits of these chickens are their ability to scavenge for feed, adaptation to household leftover, littler space to rest at night. Their meat and eggs taste are preferred over those of exotic chickens (Roberts, 1999; Dessie and Ogle, 2001).

There is no single ecotype that combines the ability of good egg traits, fertility, hatchability, survivability and high egg production (Msoffe *et al.*, 2001; Fayeye *et al.*, 2005). There is evidence that size of eggs has effect on the incubation, embryonic deaths and hatchability of broiler chickens (Malago and Baitilwake, 2009), quail (Petek and Dikmen, 2004) and rock partridges

(Caglayan *et al*., 2009). However, not much study has been done on the factors influencing the embryonic deaths and hatchability of the indigenous Venda chickens, thus the objective of the study was to determine the effect of egg weight on physical egg parameters and hatchability of indigenous Venda chickens.

MATERIALS AND METHODS

This research was conducted between December 2010 and March 2011 at the experimental farm of the University of Limpopo, South Africa. The farm is situated 10 km North-west of the Turfloop campus of the University of Limpopo. The ambient temperatures around the area are above 30°C during summer and below 25°C in winter.

A total of 690 hatching indigenous Venda chicken eggs obtained from the Agriculture Research Council (ARC), Irene, Pretoria were used for this experiment. A complete randomized design was used for this experiment. The eggs were classified into three Treatment groups as large (≤50 g), medium (44-49 g) and small (≤45 g), replicated three times (Table 1). A 0.01 g sensitivity level electronic scale (RADWAG) was used to weigh the eggs. Eggs were fumigated with formalin potassium permaganent in a ratio 1:2 for 15 min before they were placed in an incubator. The egg physical parameters were measured as follows: The egg length and width were measured with the aid of the digital calliper; the shape indexes of the eggs were calculated using the following formula given by Panda (1996):

$$\text{Egg shape index} = \text{egg width/egg length}$$

The egg volume was determined using the equation derived by Narushin (2005):

$$V = (0.6057 - 0.0018B)\ LB^2$$

where, V is egg volume, B is egg breath and L is egg width

The egg density was determine by the following equation: Egg density (g/cm^3) = Egg weight (g) divided by egg volume (cm^3). The weights of the eggs were taken at the 18th day of incubation to calculate the weight loss and its percentage.

The eggs were placed in an incubator with the broad end pointing upwards. The temperature and humidity were set to 37.5°C and 82.5%, respectively for incubation and 37.0°C and 85% for hatching.

Embryonic mortality: On the 18th day of incubation, the eggs were candled and those with evidence of living embryos were recorded for the different egg Treatments and transferred to the hatcher. The remaining eggs were candled and then broken for microscopic analysis to distinguish the eggs containing dead embryos from the infertile eggs. Dead embryos were recorded and

Table 1: Egg weights of the treatments

Treatments	No. of eggs	Mean	SE	Min	Max
(A) >50 g	230	55.37	±0.20	51.17	59.57
(B) 45-50 g	230	49.36	±0.64	48.73	50.00
(C) <45	230	44.23	±0.73	43.44	44.90

SE: Standard error

classified as early, medium and late. Those estimated to have died during less than 8 days of incubation were referred to as early. While medium embryonic deaths were those estimated to have died between 8-17 days of incubation. At the end of incubation (21 days) hatched chicks were recorded for the different Treatments. The eggs in which the embryos failed to hatch were classified as late embryonic deaths.

All this data was used to calculate percentage mortality (Total, early, medium and late embryonic deaths).

Hatchability: The percentage fertility rate, hatching yield and hatchability were calculated using the following formulas given by Sahin *et al.* (2009):

$$\text{Fertility rate percentage} = \frac{\text{No. of fertile eggs}}{\text{No. of eggs loaded int o the incubator}} \times 100$$

$$\text{Hatching yield percentage} = \frac{\text{No. of chicks hatched}}{\text{No. of eggs loaded int o the incubator}} \times 100$$

$$\text{Hatchability of fertile eggs} = \frac{\text{No. of fertile eggs}}{\text{No. of eggs loaded int o the incubator}} \times 100$$

Statistical analysis: Effect of weight on hatchability of Venda chicken eggs was analysed using the general linear model procedure of the statistical analysis system (SAS, 2008). The statistical model used was:

$$Y_{ijk} = \mu + T_i + \Sigma_{ijk}$$

Where:

Y_{ijk} = The overall observation (fertility, embryonic dead, hatching yield and hatchability)
T_i = Effect of different egg weight (small, medium and large):
Σ_{ijk} = Residual effect

Duncan's test for multiple comparisons was used to test the significant difference between Treatment means ($p<0.05$). The responses in optimum fertility rate, embryonic deaths hatching yield and hatchability to egg weight were modelled using the following quadratic Equation:

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

Where, Y is optimum fertility, embryonic dead, hatching yield and hatchability, a is intersect, b_1 and b_2 is coefficents of quadratic equation, x is egg weight and $-b_1/b_2$ is x value for optimum egg size.

RESULTS

The results of the effects of egg weight on physical parameters are presented in Table 2. Egg weight had effects ($p<0.05$) on length, volume, density and weight loss of indigenous Venda chicken eggs. Egg weight, however, did not ($p>0.05$) have effect on egg width and shape index.

Table 2: Effect of egg weight on egg physical parameters

Parameters	A	B	C	Mean	SE	Min	Max	p-value
Egg weight (g)	55.37[a]	49.36[b]	44.23[c]	49.18	0.89	39.2	60.4	0.008
Egg length (mm)	6.07[a]	6.02[a]	5.53[b]	5.87	0.18	5.49	6.3	0.001
Egg width (mm)	4.28	4.27	4.09	4.21	0.12	3.97	4.38	0.225
Egg shape index	0.71	0.71	0.74	0.72	0.07	0.07	0.78	0.719
Egg volume (cm^3)	65.89[a]	65.63[a]	55.54[b]	62.35	1.02	0.55	77.25	0.001
Egg density ($g\ cm^{-3}$)	84.01[a]	75.24[b]	77.14[a]	78.80	0.07	0.71	0.86	0.012
Egg weight loss (%)	24.18[a]	19.56[b]	9.49[c]	17.74	0.85	9.43	24.66	0.001

[a, b, c] Means in the same row not sharing a common superscript are significantly different ($p<0.05$). SE: Standard error

Table 3: Effect of egg weight on hatchability parameters

Parameters	A	B	C	Mean	SE	Min	Max	p-value
Fertility rate (%)	96.39	93.33	90.83	93.52	3.50	88.33	99..17	0.146
Embryonic death (%)	44.29[a]	18.11[c]	29.36[b]	30.58	11.73	14.81	48.74	0.001
Early embryonic death (%)	28.75[a]	8.91[c]	18.06[b]	18.57	8.82	7.14	31.03	0.001
Medium embryonic death (%)	5.49[a]	2.39[b]	3.65[ab]	3.84	1.71	0.89	6.90	0.050
Late embryonic death (%)	10.05[a]	6.56[b]	7.64[ab]	8.08	2.15	5.50	12.61	0.050
Hatching yield (%)	53.611[c]	76.39[a]	64.17[b]	64.90	1.03	54.07	76.48	0.001
Hatchability (%)	55.71[c]	81.89[a]	70.64[b]	70.39	1.07	56.54	81.99	0.001
Hatch-weight (g)	35.32	30.90	28.20	31.47	1.046	27.27	37.15	0.002

[a, b, c] Means in the same row not sharing a common superscript are significantly different ($p<0.05$). SE: Standard error

The length of eggs in Treatments A and B (6.07 and 6.02) mm, respectively, were similar ($p>0.05$) and longer ($p<0.05$), then those from Treatment C. Volumes of eggs in Treatments A and B (65.89 and 65.63 cm^3, respectively) are similar ($p>0.05$) and bigger ($p<0.05$) than those from Treatment C. The densities of eggs in Treatments A (84.01 $g\ cm^{-3}$) and C (77.14 $g\ cm^{-3}$) were similar ($p>0.05$) but those in Treatment B were lower ($p<0.05$) than those from eggs in Treatments A and C. Large size eggs (Treatment A) experienced higher ($p<0.05$) egg weight losses than did the medium size eggs (Treatment B). Similarly, medium size eggs (Treatment B) experienced higher ($p<0.05$) egg weight losses than did the small size eggs (Treatment C).

Egg weight size had no effect ($p>0.05$) on the fertility rate. However, egg weight size affected ($p<0.05$) all the other parameters (Table 3).

Large eggs (Treatment A) had higher ($p<0.05$) early and total embryonic deaths, hatching yield and hatchability than large eggs (Treatment C). Similarly, large eggs had higher ($p<0.05$) early and total embryonic deaths, hatching yield and hatchability than medium size eggs (Treatment B). Small and large eggs had similar ($p>0.05$) medium and late embryonic deaths. Similarly, medium and large eggs had similar ($p>0.05$) medium and late embryonic deaths. However, small eggs had higher ($p<0.05$) medium and late embryonic deaths than medium size eggs. The hatch-weight of the indigenous Venda chickens increased as the egg weight increases. The big size eggs had higher ($p<0.05$) chick weight (35.32 g) than the medium size eggs (30.90) which in turn had higher ($p<0.05$) chick weight than the small size eggs (28.20).

Table 4 revives that the total, early, medium and late embryonic deaths were optimized in eggs weighing approximately 48 g. Similarly, the hatching yield and hatchability were also, optimized in eggs weighing 48 g.

Table 4: Effect of egg weight (g) on optimal embryonic death, hatching yield and hatchability percentages

Trait (%)	Formula	R^2 values	Optimum egg weight	Y- value
Total embryonic death	$Y = 1121.562\text{-}46.14X+0.482X^2$	0.99	47.86307	17.36
Early embryonic death	$Y = 864.203\text{-}35.69X+0.372X^2$	0.98	47.97043	8.17
Medium embryonic death	$Y = 130.358\text{-}5.359X+0.056X^2$	0.95	47.84821	2.15
Late embryonic death	$Y = 139.589\text{-}5.611+0.059X^2$	0.99	47.55085	6.19
Hatching yield	$Y = \text{-}963.103+43.183\text{-}0.448X^2$	0.95	48.19531	77.51
Hatchability	$Y = \text{-}1019.87+46.069\text{-} 0.481X^2$	0.99	47.88877	83.22

DISCUSSION

One of the most influential parameters of hatchability is egg weight (King'ori, 2011), the egg weights used in this study ranged between 39.20 and 60.4 g. These weights cover the average weight of 52.2 g reported for Venda chicken eggs by Fourie and Grobbelaar (2003). These weights were, also, within the range reported by other authors for indigenous chickens (Olwande *et al*., 2010; Msoffe *et al*., 2001; Yami, 1995). However, they are higher than those reported by Adedokun and Sonaiya (2001). This might be due to breed differences. The egg lengths observed in this study were longer than the 35.24 mm reported by Fayeye *et al*. (2005), they were also, longer than those reported by Farooq *et al*. (2001) for Desi, Fayumi and Rhode Island Red (RIR) chickens. This might also be as a result of breed differences as reported by Caglayan *et al*. (2009) and Wondmeneh *et al*. (2011). The egg volume increased with increase in egg weight though there were only significant difference between Treatments A and C; B and C. Sahin *et al*. (2009) observed similar trends. Malago and Baitilwake (2009) reported a positive correlation between egg weight and volume. The egg density also increased as the egg weight increased, this is in line with the finding of Sahin *et al*. (2009). The egg weight loss increased as the weight of the egg increases. The average egg weight loss is similar to 15.48% reported by Caglayan *et al*. (2009). Similarly, Tona *et al*. (2001) observed that egg weight and absolute egg weight loss increased concomitantly. This might be attributed to similar egg weight and pore spaces of the eggs used in the study.

Very high egg fertility rates, ranging from 91 to 96%, were observed in the present study, this rate is similar to those reported by Kamanli *et al*. (2010) and Islam *et al*. (2002). It was, also, observed in the present study that the egg fertility was not affected by egg size of indigenous Venda chickens. This is similar to the observations made by Petek *et al*. (2005) in quils, Sahin *et al*. (2009) in breeder hens and Kamanli *et al*. (2010) for ATAK-S Brown layers but contrary to the findings of Caglayan *et al*. (2009) in rock partridge. The highest embryonic deaths occurred in small and large Venda chicken eggs. Thus, generally the lowest embryonic deaths occurred in medium size eggs. These were the same eggs which exhibited higher egg hatching yield and hatchability values. These are similar to the findings of Gonzalez *et al*. (1999) in ostrich and Abiola *et al*. (2008) in broiler chickens and quails, respectively.

The lowest embryonic deaths in Vends chicken eggs were estimated to occur in eggs weighing 48 g. This coincided with egg weight loss during incubation around 16.56%. The present observations are similar to the findings of Caglayan *et al*. (2009) and Hassan *et al*. (2005) in rock partridges and ostrich, respectively. Result of the hatch-weight in the study is in line with those of Abiola *et al*. (2008) and Caglayan *et al*. (2009) that observed a positive correlation between egg size and chick hatch weight in broiler chickens and rock partridge, respectively.

Optimum hatching yield and hatchability of indigenous Venda chicken eggs were at egg weight of 48 g. This implies that Venda chicken eggs for hatching have to be sorted out into this weight for optimal hatchability. Kalita (1994) and Abiola *et al*. (2008) also showed that the best hatching values were achieved with the medium size eggs in broiler chickens.

CONCLUSION

It is concluded that lowest embryonic deaths occurred in Venda chicken eggs weights of 48 g. Similarly, hatching yield and hatchability values were optimized in the Venda chicken eggs weighting 48 g. It is suggested that Venda chicken eggs weighing 48 g should be used for breeding.

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