Egg traits, fertility, hatchability and chick survivability of Rhode Island Red, local and crossbred chickens

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SUMMARY

The local chicken has profound potential for upgrading through cross breeding with improved commercial birds to increase meat and egg production. This study aimed at evaluating egg traits, hatchability, fertility, chick hatch weight, and chick survivability of commercial Rhode Island Red (RIR), local, and crossbred chickens. A total of 6752 local chicken eggs were collected to obtain breeding stock and to study egg traits. RIR breeding stock was obtained from raising 250 (50 males, 200 females) while crossbred chickens were obtained by crossing RIR layer cocks to local hens and vice versa. A total of 1382, 1523, and 1476 local, RIR, and crossbred chicken eggs respectively were assessed for egg weight, length, breadth, and volume as well as chick hatch weight. Fertility and hatchability were assessed in 3675 local chicken eggs and 3350 eggs from RIR and crossbred chicken each. There was no significant difference ($p < 0.05$) in egg traits and chick hatch weight between RIR and crossbred chickens but these birds had significantly higher egg weight, egg length, egg breadth, egg volume, and chick hatch weight than local chickens. There were significant ($p < 0.0001$) positive relationships between egg volume and egg weight, chick hatch weight and egg weight, and chick hatch weight and egg volume for all chickens. Fertility was 92.0±4.14, 91.1±4.42, and 94.5±2.21 for local, RIR, and crossbred chickens respectively. Hatchability varied significantly at $p<0.05$ (80.6±1.43 in crossbred, 64.0±2.16 in RIR, and 52.2±2.54 in local chickens). Survivability of local chicks was superior by 50% over RIR and crossbred chicks. It is concluded that cross breeding local chickens to RIR produces a superior breed to local ecotype in terms of egg traits, hatchability and survivability. Such superiority can be exploited to upgrade the genetic potential of local ecotype and thus improve poultry production.

INTRODUCTION

Local chickens are kept in many parts of the world irrespectively of the climate, traditions, life standard, or religious taboos relating to consumption of eggs and chicken meat like those for pig meat (Tadelle, 2003). To the poor majority in rural areas, local chickens serve as an immediate source of meat and income when money is needed for urgent family needs (Ekue *et al*., 2002). It constitutes a significant contribution to human livelihood and contributes significantly to food security (Gondwe, 2004). Women and sometimes youths are the mostly involved in keeping these chickens. The local chickens are known for various merits. They are cheaply reared as scavenging flocks by feeding household leftovers, they need a small house or shelter to spend their night while free ranging during the day, and their meat and egg tastes are preferred over those of exotic chickens (Roberts, 1999; Dessie and Ogle, 2001). Most important, they are known for their adaptation superiority in terms of their resistance to endemic diseases and other harsh environmental conditions. However, local chickens are poor performers in terms of growth rate (hence meat production) and egg production. Most of them are of small adult size and lay small sized eggs when compared to improved commercial broiler or layer birds respectively (Pedersen, 2002; Gondwe, 2004).

What is generally referred to as local chickens is a pool of heterogeneous individuals which differ in adult body size, weight and plumage. They are of several ecotypes that are distinct. Their performance vary considerably and no single ecotype meets the attributes of good egg traits, fertility, hatchability, survivability, high growth rate, heavy weight at slaughter and high egg production (Msoffe *et al.,* 2001; Fayeye *et al.,* 2005). Fortunately, their genetic diversity could be exploited to improve their productivity. It is therefore a laudable proposition that more attention should be given to the genetic improvement and development of the local chicken in order to ameliorate the present acute animal protein shortage to many poor societies around the globe.

One way of improving the local chicken is by cross breeding with improved commercial breeds. In Nigeria, cross breeding local fowls to commercial Rhode Island Red (RIR) chicken produced Fulani-ecotype chicken (Ogundipe, 1990; Tiamiyu, 1999) that is superior to other local ecotypes within Nigeria in terms of egg traits, hatchability, growth performance and live weight (Atteh, 1999; Fayeye 2005). Such improvements provide potentially good ecotypes for meat and egg production and could thus help to develop improved local strains. Studies on improvement of local chickens are rarely reported in other parts of the world including Tanzania. Stemming on the importance of local chicken to the economy of the poor majority in Tanzania, this study was designed to gather preliminary information on the feasibility of improving the local chicken by cross breeding with the commercial RIR. The study explored and compared egg traits, fertility, hatchability, chick hatch weight, and chick survivability for local, RIR, and crossbred chickens.

MATERIALS AND METHODS

Source of chickens and sample size

A total of 250 (200 females and 50 males) day old chicks of exotic layer breed, Rhode Island Red (RIR), purchased from a local agent were raised to serve a breeding purpose. To obtain local chickens and to study the egg traits of these birds, a total of 6752 local chicken eggs collected from Morogoro urban (2803), villages around Mgeta (3024), and Mamvisi village of Kidete ward, Kilosa (925) (all in Morogoro region, Tanzania) were sorted, incubated, hatched and the chicks grown as local chicken breeding stock. Crossbred chickens were obtained by crossing RIR layer cocks to local hens and vice versa.

Egg measurements

All eggs for incubation were sorted against cracks, morphological deformities, and dirty (soiled) before acquiring egg weight, egg length, egg breadth, and egg volume. A total of 1382, 1523, and 1476 local, RIR, and crossbred chicken eggs respectively were assessed. Eggs were weighed to the nearest 0.10 gram on a digital scale (Mettler Instrumente AG, Zurich, Switzerland) while egg length and egg breadth were measured to the nearest 0.10 cm using a pair of vernier callipers (GT Tools, Japan). The values of the egg length (L) and egg breadth (B) were used to determine the egg volume (V) (cm^3) using Hoyt's (1979) equation ($V=Kv*LB^2$) where the estimated volume coefficient (Kv=0.507) is applicable to all eggs which are not very pointed.

Incubation

Eggs of medium size were incubated in an automated electrical incubator of 1350 egg capacity (Kalambo ET, Kibaha, Tanzania) at 37°C and 60-65% relative humidity and turning hourly. Candling was done on day 5 and 18 to determine infertile eggs ('clears') and dead embryos, respectively. The latter were confirmed by breaking the eggs after 21 days. Eggs with living embryos were then transferred to the hatching chamber of the incubator. Hatched chicks and those assisted to hatch by breaking the egg shell were collected, counted and weighed to the nearest 0.10 gram on a digital scale to determine the chick hatch weight.

Fertility and hatchability

Both fertility and hatchability were determined in 3675 local chicken eggs and 3350 for RIR and crossbred each. Fertility was determined as 100[number of fertile eggs]/number of total eggs set; while hatchability was determined from the formula: Hatchability = 100[number of chicks hatched]/number of fertile eggs set.

Housing, diet and disease control

Hatched chicks were raised on electrically heated brooder for three weeks. The birds were kept intensively and adults were stocked at 10 birds/m^2. They were fed on formulated chick mash (0-8 weeks), growers mash (9-20 weeks) and layers mash (21 weeks onwards) (Table 1) with calculated nutrient composition indicated in Table 2.

Table 1. Composition of chicken feeds

Ingredient	Percent in diet of chicken feeds		
	Chick	Growers	Layers
Maize	38.0	41.0	45.0
Maize bran	10.0	12.0	11.5
Rice bran	17.0	20.0	19.0
Sunflower seed cake	12.5	10.0	10.0
Cotton seed cake	7.0	7.0	5.0
Fish meal	11	5.5	2.0
Layers premix	0.5	0.5	0.5
Limestone	1.0	1.0	2.5
Salt	0.5	0.5	0.5
Bone meal	1.0	1.0	2.5
Methionine	0.5	0.5	0.5
Lysine	1.0	1.0	1.0

Feed and water were supplied *ad libitum* throughout the experimental period. Vaccinations were done against Newcastle disease by using a live vaccine of La Sota strain (Laboratorios Hipraviar, S.A., Awer, Spain) on day 7, day 21, week 8, and then every 3 months, and Infectious Bursal disease by using a live vaccine of Geb-10 strain (Shafit Biological Laboratories Ltd, Kibbutz Shefayim, Israel) on day 14 and 28. From 4 months old, birds were routinely dewormed every 3 months by piperazine citrate (Kela Laboratoria, Belgium). Where necessary, birds were treated against coccidiosis by amprolium (Laprovet, 37075 Tours Cedex 2, France) and bacterial infections by oxytetracyclin (Laprovet, 37075 Tours Cedex 2, France).

Table 2. Calculated nutrient contents in chicken feeds

Nutrient content	Amount		
	Chick	Growers	Layers
Crude protein (%)	20	16	16.5
Metabolizable energy (kcal/kg)	2892.6	2928.7	2962.7
Crude fibre (%)	7.9	7.8	7.4
Crude fat (%)	3.7	3.5	3.5
Calcium (%)	1.2	1.2	3.5
Phosphorus (%)	0.2	0.2	0.6

Breeding stock

At 20 weeks of age, good looking birds were selected as breeding stocks. For crossbreds, two groups of breeding stocks were maintained. One group involved RIR hens being crossed with local cocks while the second composed of local hens being crossed with RIR cocks. In all experiments, the hen to cock ratio was kept at 10:1 and at least 100 hens and 10 cocks were kept per group.

Statistical analysis

Mean egg weight, egg length, egg breadth, egg volume, chick hatch weight, hatchability, fertility and chick survivability for local, RIR and crossbred chicks was calculated using excel program of Microsoft office 2007. The values were analysed in one-way ANOVA by Duncan's multiple range test using PROC GLM of SAS. Simple linear regressions were calculated to evaluate the relationship between egg weight and chick hatch weight, egg volume and chick hatch weight, as well as egg weight and egg volume. Significance for all tests was $p<0.05$ unless stated otherwise.

RESULTS

Egg parameters

When egg weight, length, breadth, volume, and chick hatch weights were compared across RIR, local, and crossbred chickens (Table 3), significant differences were found over the breeds. Both eggs of RIR and crossbreds were significantly heavier than the local chicken egg ($p<0.05$). Eggs of RIR did not differ significantly with those of crossbred. There was a significant difference in egg length, with the egg of the RIR being significantly longer than the local chicken egg ($p<0.05$). The length of the local chicken egg did not differ from that of crossbred. There was also no significant difference in the length of RIR eggs as compared to those from crossbred. Calculated egg volume was significantly higher in RIR and crossbred than in local chickens.

The chick hatch weight was significantly ($p<0.05$) smaller in local breed than in RIR and crossbred. There was no chick hatch weight difference between RIR and crossbred chickens (Table 3).

Table 3. Comparisons of mean weight, length, breadth, and volume of incubated eggs and hatch weights of chicks from the Rhode Island Red (RIR), local and crossbred chickens

Breed	n	Egg weight (g)	Egg length (cm)	Egg breadth (cm)	Egg volume (cm^3)	Chick hatch weight (g)
RIR	1523	60.58±4.55	5.66±0.18	4.37±0.10	54.88±3.89	30.12±2.86
Local	1382	41.18±3.93	5.14±0.25	3.83±0.14	38.43±4.17	23.71±1.72
Crossbred	1476	58.42±6.88	5.58±0.48	4.29±0.15	52.07±5.06	28.54±2.00

All data are mean ± SD

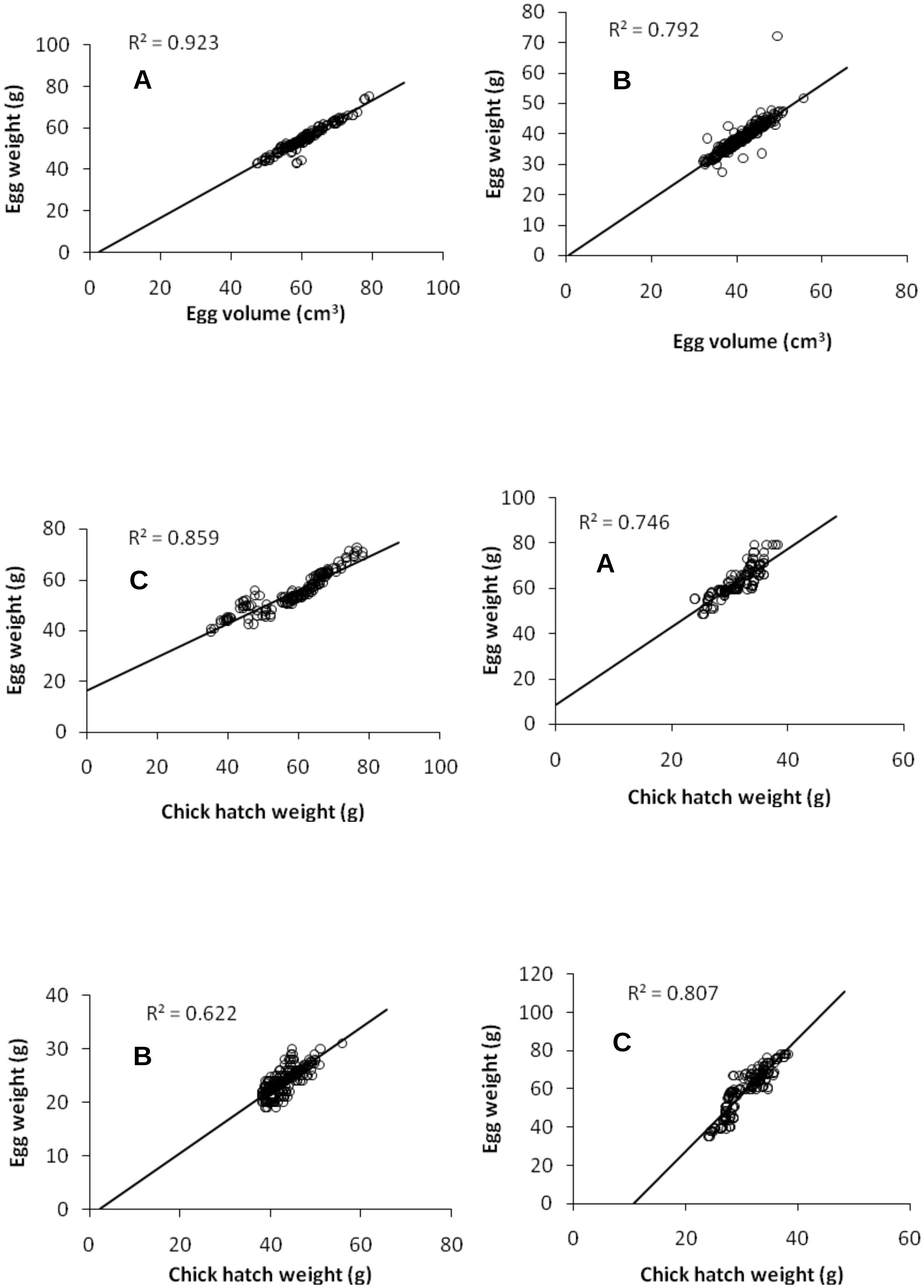
The size range of incubated eggs in comparison to that of chick hatch weights is presented in Table 4. While the RIR had the heaviest (70.07 g) and largest eggs (63.02 cm^3), local chicken had the lightest (32.1 g) and smallest (30.8 cm^3) eggs. On the contrary, the heaviest (35.62 g) chick was from a local chicken egg and the lightest (21.19 g) chick was from a crossbred chicken egg.

Table 4. Range of egg weight, length, breadth, volume of incubated eggs and hatch weight of chicks from the Rhode Island Red (RIR), local and crossbred chickens

Breed	Egg weight	Egg length	Egg breadth	Egg volume	Chick hatch weight
RIR	70.07-55.27	5.90-5.62	4.59-4.20	63.02-50.26	34.16-24.18
Local	55.70-32.10	5.85-4.82	4.17-3.55	51.57-30.80	35.62-23.03
Crossbred	65.6-48.80	6.09-4.50	4.27-4.45	56.30-45.18	31.38-21.19

All data are means

There were significant positive relationships (Figure 1) between egg volume and egg weight (R^2=0.923 for RIR; R^2=0.792 for local chicken; R^2=0.859 for crossbred; all at $p<0.0001$), between chick hatch weight and egg weight (R^2=0.746 for RIR; R^2=0.622 for local chicken; R^2=0.807 for crossbred; all at $p<0.0001$) and chick hatch weight and egg volume (R^2=0.684 for RIR; R^2= 0.706 for local chicken; R^2=0.734 for crossbred; all at $p<0.0001$).



R^2 = 0.923
A
Egg weight (g)
Egg volume (cm^3)
R^2 = 0.792
B
Egg weight (g)
Egg volume (cm^3)
R^2 = 0.859
C
Egg weight (g)
Chick hatch weight (g)
R^2 = 0.746
A
Egg weight (g)
Chick hatch weight (g)
R^2 = 0.622
B
Egg weight (g)
Chick hatch weight (g)
R^2 = 0.807
C
Egg weight (g)
Chick hatch weight (g)

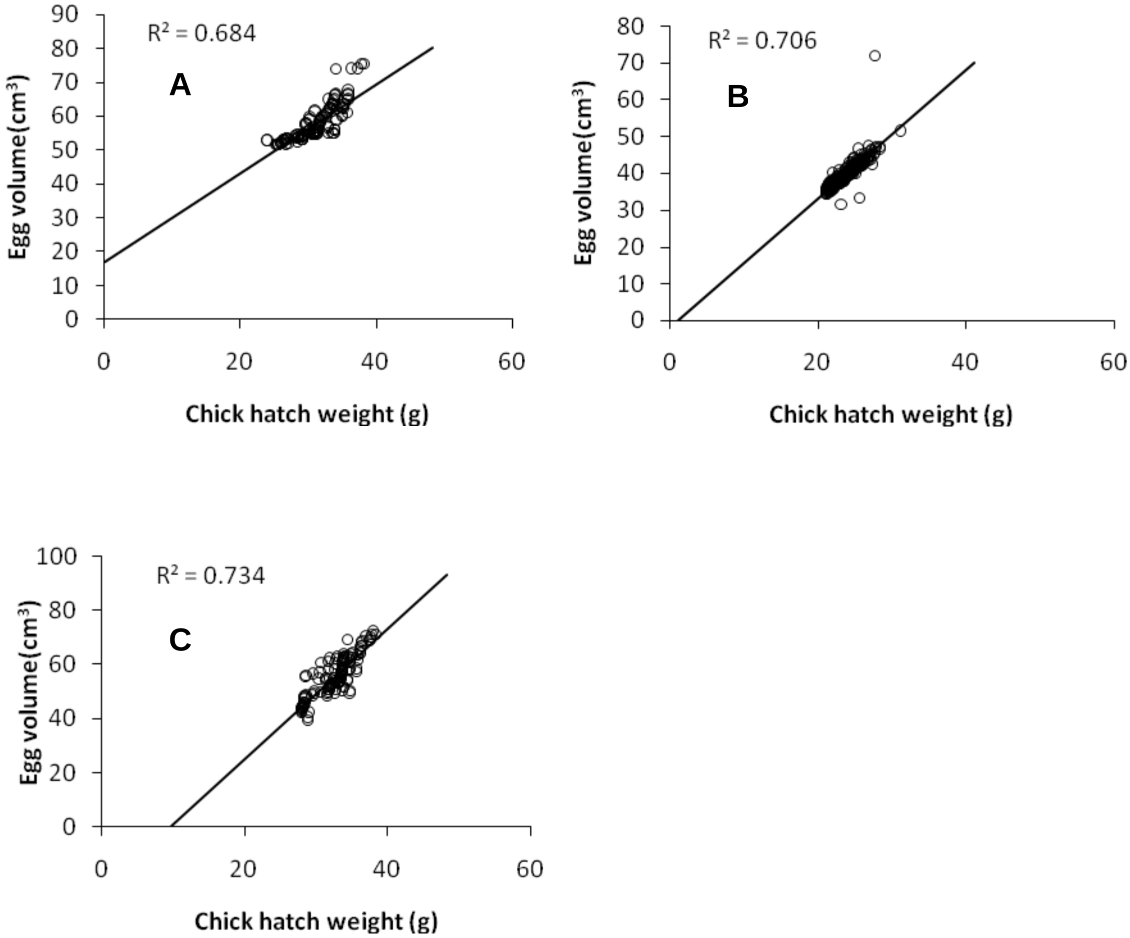


Figure 1. Relationships between egg volume and egg weight; chick hatch weight and egg weight; and chick hatch weight and egg volume for Rhode Island Red (A), local (B), and crossbred (C) chickens. All relationships were significant different ($p<0.0001$). RIR, Rhode Island Red.

Fertility and hatchability

Mean fertility was 92.0% (± 4.14 SE), 91.1% (± 4.42), and 94.5% (± 2.21) for local, RIR and crossbred chickens respectively (Figure 2). There was no significant difference in fertility among the different chicken breeds ($p<0.05$).

Among fertile eggs, mean hatchability was 52.2% (±2.54 SE), 64.0% (± 2.16), and 80.6% (± 1.43) for local, RIR, and crossbred chickens respectively (Figure 2). Comparisons between breeds revealed significant differences in hatchability among the breeds.

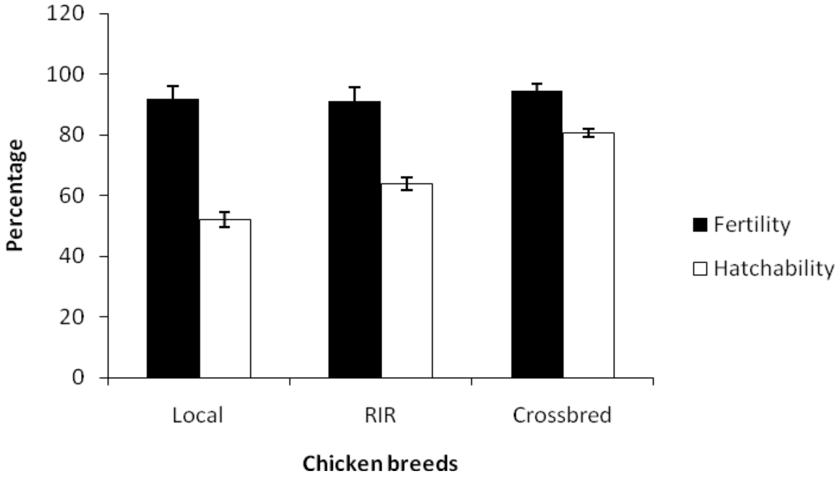


Figure 2: Fertility and hatchability of Rhode Island Red (RIR), local and crossbred chickens

Products of incubated fertile eggs

Half of the fertile eggs from local chicken, 60.6% from RIR and 76.8% from crossbred hatched into healthy chicks. The variations were significantly different (p<0.05%) (Figure 3). There was no difference between local (about 15%) and crossbred chicken eggs (about 18%) that underwent early embryonic death. However, there was a significant difference with eggs from RIR undergoing early embryonic death (2%). The number of eggs with late embryonic death from local (33%) and RIR (34%) chickens did not differ statistically but were significantly higher than those of crossbred by almost 30 folds. About 4% of chicks from crossbred fertile eggs were assisted to hatch. This was twice as much as those from local chicken and was significantly different. The percentage was also significantly higher (p<0.05) than that of RIR. When compared to local chicken, the percentage of assisted chicks from RIR eggs was significantly higher.

Nearly all chicks that hatched without assistance (RIR 97.1±1.34%; local 98.0±1.09%; crossbred 98.0±1.19%) survived the 8 weeks without any significant difference over the breeds. Variations in survivability were noted between local and RIR and between local and crossbred chicks that were assisted to hatch (Figure 4). In these variations, survivability of local chicks was higher (p<0.05) than either of the other breeds. There was no difference in survivability between RIR and crossbred assisted chicks in the 8 weeks of age.

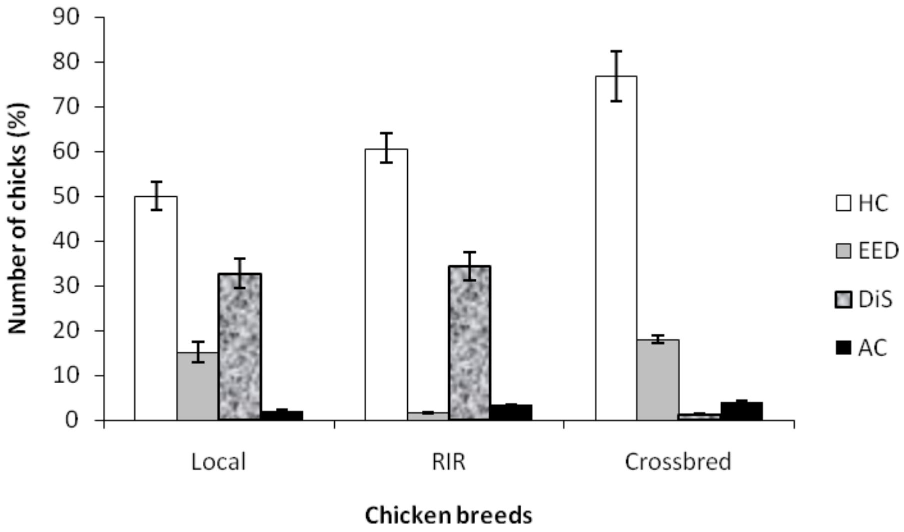


Figure 3. Products of incubated fertile eggs from Rhode Island Red (RIR), local and crossbred chickens. HC, hatched chicks without assistance; EED, early embryonic death; DiS, dead-in-shell chicks (i.e. late embryonic death); AC, chicks assisted to hatch.

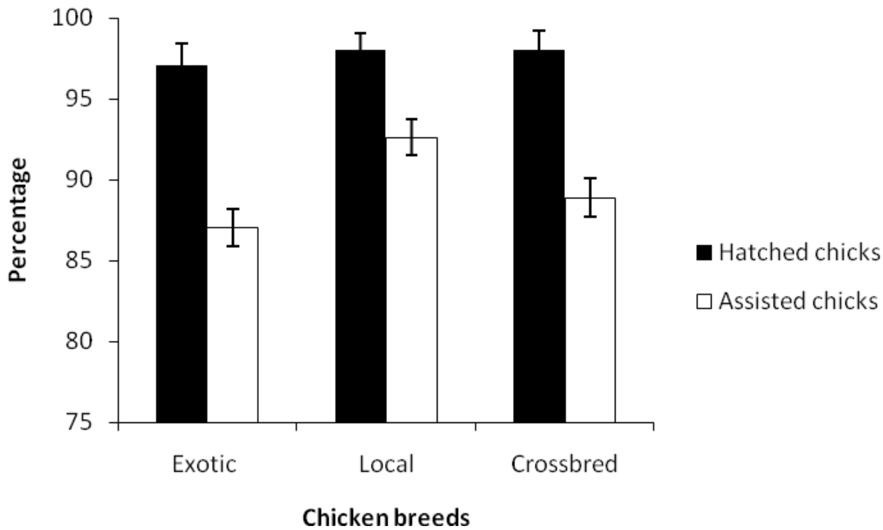


Figure 4. Chick survivability (0-8 weeks) of Rhode Island Red (RIR), local, and crossbred chickens.

Chick death

A total of 75 (2.8%, n = 2676) chicks died during the first 8 weeks of age. Of these, 68% died in the first 4 weeks. Large percentage (38.7) of dead chicks in the first 4 weeks was from chicks assisted to hatch while in the next 4 weeks they (21.3) were from hatched chicks without assistance (Table 5). When compared among the breeds, the total percentage of RIR or crossbred chicks that died in the first or second month was about twice that of local chicks. There was a significant difference ($p<0.05$) in percentage chick death between hatched chicks and those assisted to hatch in local and crossbred but not in RIR. In the first month the percentage of dead assisted chicks from local or crossbred chickens was almost twice as much as that in hatched chicks while it was five times higher in the second month.

Table 5. Mean percentage dead chicks of Rhode Island Red (RIR), local, and crossbred chickens within 8 weeks of age

	Chicks dead in first month (%)				Chicks dead in second month (%)			
	Local	RIR	Crossbred	Total	Local	RIR	Crossbred	Total
Hatched chicks	5.3±0.2	14.7±1.2	9.3±0.7	29.3±2.2	5.3±0.4	5.3±0.6	10.7±1.2	21.3±2.5
Assisted chicks	9.3±1.1	13.3±1.5	16.0±1.4	38.7±2.8	1.3±0.1	6.7±0.8	2.7±0.3	10.7±1.2
Total	14.7±1.4	28.0±2.1	25.3±3.8	68.0±4.8	6.7±0.7	12.0±1.3	13.3±1.2	32.0±2.6

DISCUSSION

The mean egg weight of local chicken in the present study was consistent to values reported by others. According to Msoffe *et al.* (2001) mean egg weights of Tanzanian local chicken ecotypes range from 37.65 to 45.61 g for medium and heavy breeds while Odula *et al.* (2009) reported mean egg weights of 45 and 48 g in local chickens differing in weights in two locations in Kenya. The higher egg weight in RIR than local and crossbred chicken could be attributed to its genetic potential for the production of large sized eggs. In addition, RIR is a well established breed than local or the crossbred chicken and selection for better egg size might have been made generation after generation. Calculations to estimate egg volume by relating egg length and breadth adopted by other researchers (Mänd, 1988; Narushin and Romanov, 2002; Narushin, 2005) have revealed a positive correlation between egg weight and egg volume. Consistently, this study reports a positive correlation of egg weight and volume.

The higher mean weight of newborn chick in RIR than in local and crossbred chicken could probably be due to larger RIR egg weight and size than that from local and crossbred chickens as is evident from Table 3. In fact results in this study show significant ($p < 0.05$) and positive correlation of egg weight with chick hatch weight for RIR, local and crossbred chickens (Figure 1) suggesting that increased egg weight will result in increased hatching chick weight. Farooq *et al.* (2001) also reported positive correlation ($r=0.4962$) of egg weight with hatching chick weight in RIR and scavenger Desi and Fayumi chickens in Pakistan. Similarly, Narkhede *et al.* (1981) reported a positive correlation ($r=0.93$) of egg weight with hatching chick weight in crossbred chicken (Rhode Island Red x White Leg Horn).

Comparable data is missing on fertility in local Tanzanian chicken. It is interesting to note, however, a similar fertility in local, RIR, and crossbred chickens (Figure 2).

Our results are consistent with other researchers who reported high fertility levels of 95.5% in scavenging chicken (Murad *et al.,* 2001) and 96.11% in commercial layer chicken (Islam *et al.*, 2002; Zelleke *et al.,* 2005). These studies and several others have shown that fertility can highly vary even within the same breed mainly due to poor management and improper proportion of males or poor ability of males in the flock to produce viable sperms. The results of the present study alludes that the 1:10 cock to hen proportion in RIR and crossbred chickens brought a similar fertility to that of natural mating in local chicken and that local Tanzanian chicken ecotypes are potentially as fertile as improved commercial chickens like RIR.

Hatchability of local chickens under natural brooding has been reported to be 83.6% in Tanzania (Mwalusanya *et al*., 2002) and 70% and 81% in two locations in Kenya (Odula *et al.,* 2009). These values are higher than the ones observed in this study (52.2±2.54%). On the other hand, hatchability for RIR eggs reported in this study (80.6±1.43%) was consistent (80.77±0.10%) to that reported by Farooq *et al.* (2001). Variations in hatchability can be accounted for by various factors. Farooq *et al.* (2000) observed that hatchability of scavenging chicken maintained by untrained farmers is low (60.00±0.18%) and high (84.05%) for trained farmers. Several other researchers have reported that hatchability decreases with increasing egg storage period as percentage early and late embryonic mortality increases (Brake *et al.,* 1997; Elibol *et al.,* 2002; Elibol and Brake, 2008). Yet other studies have shown a significant effect on hatchability with regard to egg positions during storage (Elibol and Brake, 2008). Bearing in mind that eggs in the present study were collected from various farmers without formal education in poultry husbandry, management factors on egg collection, handling and storage could partly account for the low hatchability of local chicken eggs. The very same factors could have contributed to the high mortalities of local chicken embryos as evidenced in Figure 3. On the other hand, high hatchability in RIR and crossbred chickens could be attributed to good management during the experiment as well as their genetic make up for better propagation than local chickens. As opposes to local chicken eggs that were collected from untrained farmers who presumably might had some eggs stored for more than 7 days and in different positions, eggs from RIR and crossbred chickens were stored with their large end up (LEU) for utmost 7 days before incubation. This position is generally known to improve hatchability as compared to eggs stored on their sides (Oluyemi and George, 1972; Moudgal *et al.,* 1976; Elibol and Brake, 2008)

Local chickens are known for their adaptation superiority in terms of their resistance to endemic diseases and other harsh environmental conditions (Nwakpu *et al.,* 1999). This is due to their long-time developed genetic potential for survivability in harsh environment. The higher chick survivability (Figure 4) as well as less chick deaths (Table 5) in local versus RIR or crossbred chickens observed in this study could partly be due to this potential genetic adaptability. Several studies have shown high mortalities of up to 50% in local chickens even after vaccination against Newcastle disease (Permin and Pedersen 2000; Mwalusanya *et al*., 2002; Abdelqader *et al.,* 2007). They tied the high chick mortalities to mishandling and improper rearing conditions of the chicks at an early age, Newcastle disease outbreaks, predation and cold weather. Since the chickens in this study were intensively kept, most of these factors were eliminated and hence high survivability. However, the results in this study on chick survivability should be interpreted cautiously as the superiority of local chicken over RIR or exotic was observed only in chicks assisted from hatching (Figure 4) though chick deaths were far less in local chicks than in the other two breeds whether hatched with or without assistance.

In conclusion, this study has shown that crossbreeding local and commercial RIR chickens produces crossbred chicken with genetic potential for improvement of local chicken. The egg quality in terms of size and weight, the chick hatch weight, hatchability and chick survivability can significantly be improved through cross breeding. However, more studies are needed to explore other factors like growth performance, production (in terms of carcass weight and egg number), disease resistance and adaptability to harsh environment of the crossbred chicken compared to RIR and local chicken. Findings from such studies and the ones presented here could be a significant prelude to the improvement of the local chicken.

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