Iranian Journal of Applied Animal Science

Evaluating the Reproductive and Egg Production Traits of Local Chickens and Their F_1 Crosses with Rhode Island Red and Fayoumi Breeds under Farmers' Management Conditions

Research Article

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Received on: 1 May 2012
Revised on: 3 Sep 2012
Accepted on: 27 Sep 2012
Online Published on: Jun 2013

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Online version is available on: www.ijas.ir

ABSTRACT

This study was conducted at Beresa watershed district of Guraghe Administrative Zone, the southern Regional State of Ethiopia to evaluate the on-farm reproductive and egg production performances of local Kei and its F_1 crosses with Fayoumi and Rhode Island Red (RIR) chicken breeds under farmers' management. The local Kei paternal line was mated with maternal lines of Fayoumi and RIR chickens to produce F_1-crosses. Twenty-four households were involved in the study who received 10 chicks from each 3 genotypes (total of 720 chicks). Three hay-box brooders fitted with chick-runs were provided to each household in which the three genotypes were reared. Eggs were collected on a daily basis and body weights were measured at 24, 34 and 52 weeks age. The highest egg fertility was observed in Fayoumi-crosses. The hatchability of total egg set and that of fertile eggs was higher for Fayoumi-crosses and local Kei chickens than for RIR-crosses. The Fayoumi (154 days) and RIR-crosses (161 days) reached age of sexual maturity earlier than local Kei chickens (183 days). The RIR-crosses were heavier ($P<0.05$) in body weight than Fayoumi-crosses and local Kei. The F_1 crosses had significantly ($P<0.05$) higher rate of egg production on hen-day and hen-housed basis than local Kei chickens. The Fayoumi-crosses produced more ($P<0.05$) eggs than RIR-crosses. The F_1 crosses produced significantly ($P<0.05$) higher total egg mass than local Kei chickens. Eggs from RIR-crosses were heavier ($P<0.05$) than Fayoumi-crosses and local Kei chickens. The F_1 crosses reached their peak egg production at about 34 weeks of age while local Kei at 38 weeks. The Fayoumi-crosses had significantly higher hen-housed and hen-day egg production rates and survival ability than RIR-crosses. In conclusion, Fayoumi breeds could be a better strategy to upgrade the poor performance of indigenous chicken populations.

KEY WORDS crossbreeding, farmers' management, Fayoumi chicken breed, local Kei chicken, Rhode Island Red chicken breed.

INTRODUCTION

The importance of scavenging local poultry production in the national economy of developing countries and its role in improving the nutritional status and income of many smallholders has been very significant (Sayda, 2012). Scavenging local chickens are more widely distributed in rural Africa than the other livestock species and they constitute the largest proportion of poultry population in most developing countries.

In Ethiopia, there are about 49.3 million chickens in the country of which 96.6% are local chickens, indicating the significance of indigenous chicken ecotypes as principal potential farm animal genetic resources of the country. These chickens have been reported to adapt very well to the traditional small-scale production system of the rural community (Halima *et al.* 2007; Moges *et al.* 2010; Melesse and Negesse, 2011). The research efforts on improvement of village poultry production have been focused on technical aspects of poultry keeping by reducing some constraints such as provision of simple shelter, locally available feed waste products, etc. (Rushton and Ngongi, 2002). As a result, although local chicken populations are more numerous than commercial type of imported poultry breeds, little research has been undertaken on village chicken production. The nutritional status and income levels of rural populations could be enhanced through improved productivity of local chicken populations. Nevertheless, compared with improved exotic chicken breeds, the general performance of local chicken populations is low. This situation could, however, be changed if the low genetic potential of local chickens is upgraded through crossbreeding programs with exotic chicken breeds. Many studies have evaluated the egg production potentials of crossbreds between local and exotic chicken genotypes with variable results under on-station conditions (Bekele *et al.* 2010; Ajayi, 2010; Melesse *et al.* 2011a; Melesse *et al.* 2011b). It was reported that the overall performance of crossbred chickens was better than local chickens.

There is the need for more studies to conclusively demonstrate the relative effect of genetic and non-genetic factors on the performance of local chickens and their F_1 crosses with exotic chicken breeds under typical farmers' management condition. Therefore, the current study was designed to evaluate the reproductive and egg production genetic potentials of local Kei chicken with its F_1 crosses of RIR and Fayoumi breeds under typical farmers' management condition.

MATERIALS AND METHODS

Description of the study area

The study was conducted from October 2008 to November 2010 at Beresa watershed district of Guraghe Administrative Zone, the southern Regional State of Ethiopia. The watershed area comprises two peasant associations, namely Beresa and Dubo-Tuto and covers an area of 1000 ha. The watershed areas are characterized as food insecure; the land is highly degraded with poor soil fertility. Agro-ecologically, the watershed is classified under the category of mid-altitude having an elevation of 1850 m a.s.l. The average annual rainfall is 1308 mm, while the mean annual temperature is 18.5 ˚C.

On-station research to produce experimental birds

Acquisition of female and male parental lines

The project started by purchasing 800 fertile eggs of Rhode Island Red (RIR) and Fayoumi chicken breeds.

The fertile eggs of RIR breed were obtained from Hawassa's Ministry of Agriculture Poultry Farm while that of Fayoumi from Debre Zeit Agricultural Research Centre, Ethiopia. At the same time, 400 fertile eggs of local Kei chicken (with red plumage feather color) were purchased from farmers of the study area. Immediately after hatching, chicks were vaccinated against New Castle Disease, Infectious Bursal Disease (IBD) and Marek's Disease. During the brooding and rearing periods, all birds were provided with standard commercial starter and grower rations, respectively at *ad libtum*.

Breeding strategy to produce experimental birds

Mating was started at 20 weeks of age using the two exotic breeds (RIR and Fayoumi) as a maternal-line and local Kei chicken as a paternal-line. Fifty cocks were randomly picked from the local Kei chicken populations and randomly divided into two groups in which the first group of 25 cocks was crossed with 100 RIR pullets and the second with 100 Fayoumi pullets (Figure 1).

The local Kei male and female chickens were mated at similar ratio to produce the Kei chicken population which served as control group. Mating was carried out in a separate blocks of house with a deep-litter housing system in which each block had five pens. Each pen was equipped with group laying nests, perches, feeders and drinkers. During mating, birds were offered standard layer ration and water *ad libtum*.

Two-thousand eggs were collected for a period of ten consecutive days from all three genotypes (local Kei, RIR-crosses and Fayoumi-crosses) and set in an incubator. Candling was carried out on the 10^{th} day and repeated on the 18^{th} day of incubation. Newcastle disease vaccination was given at hatch (ocular administration) and repeated on the 7^{th} and 21^{st} day of age and they were regularly vaccinated thereafter every three months.

On-farm management of experimental chickens

Seventy-two hay-box brooders fitted with 72 chick-runs of 10 chicks' capacity were constructed adopting the dimensions recommended by Demeke (1999). The hay-box brooders and chick-runs had dimensions of 30 × 26 × 26 cm and 30 × 56 × 56 cm, respectively. Hay was stuffed very loosely between the sides of the boxes and the top were covered with sacks filled with hay. Twenty-four randomly selected households from watershed area were involved and each received 30 chicks (10 chicks from each genotype). For each household, 3 hay-box brooders fitted with 3 chick-runs were provided to keep the three breeds separate during the brooding period. The hay-box brooders were used during the night whereas chick-runs were used to hold and feed the chicks during the day.

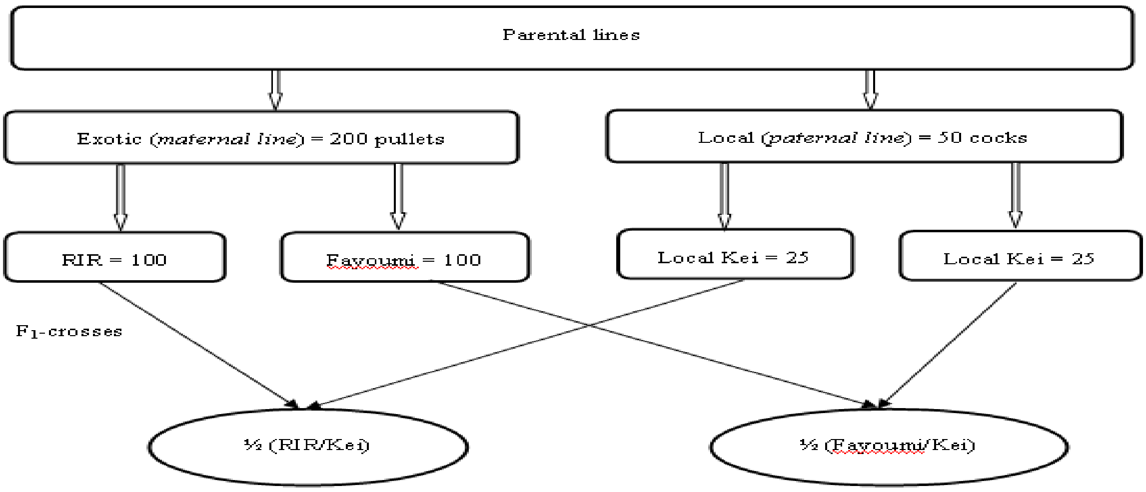

Figure 1 On-station crossbreeding arrangements to produce the F_1-crossbred combinations
RIR: Rhode Island Red chicken breed

During the brooding period (up to 8 weeks old), chicks were fed on commercial starter ration. Feed was provided to chicks using plastic cups that had been marked and distributed to the participating farmers. Feed refusals from each genotype were collected separately on daily basis using marked plastic bags. After 8 weeks age, feeding with commercial starter ration was discontinued and chicks were left to scavenge and farmers provided chickens with some whole maize and / or kitchen leftovers occasionally. Female chickens were separated from males by the size of their combs, presence or absence of wattle and tail feathers. Male birds were kept to evaluate body weight development (Misba *et al.* 2011) and female birds to evaluate the egg production performance until 52 weeks of age.

Data collection

Eggs that were incubated to produce experimental chicks were evaluated for fertility and hatchability. At the 18^{th} day of incubation, the eggs were candled and those with live embryo were transferred to the hatchery compartment. Immediately after hatching, each chick was individually leg-tagged and identified. Body weights were measured at 24, 34 and 52 weeks representing age at sexual maturity, peak egg production and end of the egg laying period respectively. The age of each individual chickens was taken and age at first egg was recorded as number of days between date of hatching and date of their first egg. The age at first egg was used to determine the sexual maturity of birds. Each household recorded the number of dead birds including the causes of death (disease or predator). Eggs were collected once daily from start to end of laying period and egg weight was determined at 28-d intervals. Percentage hen-housed egg production (HHEP) and egg mass production (EM) were then calculated using the following equation:

HHEP (%)= (total egg number/no. of birds initially housed×no. days in lay) × 100
EM (g/hen)= (total eggs number×average egg weight (g)/no. of birds initially housed) × 100

Number of survived birds at the end of the experiment was used for the calculation of percentage hen-day egg production (HDEP).

Statistical analysis

Data were subjected to analysis of variance (ANOVA) using the General Linear Models (GLM) Procedure of Statistical Analysis System (SAS, 2004). Single factor ANOVA model was used to assess the effects of genotypes on different response variables. Identification number of each chicken and the farmers in which groups of chickens were kept were the random effects when there were repeated observations per animal.
Where significant differences were observed, treatment means were compared with Duncan's Multiple Range Test. Observations on egg fertility, hatchability and mortality of the investigated birds was analyzed using the frequency procedure of Chi-square test.

All statements of statistical differences were based on $P<0.05$ unless noted otherwise.

RESULTS AND DISCUSSION

Egg fertility and hatchability traits

As presented in Table 1, egg fertility on 18^{th} day of candling was 85.8%, 80.5% and 73.4% for Fayoumi-crosses, RIR-crosses and Kei, respectively and did not differ significantly between genotypes (χ^2=0.153, P>0.05). The highest egg fertility was observed in Fayoumi-crosses and the lowest in Kei chickens.

Table 1 Average fertility and hatchability values of total eggs set and fertile eggs in three genotypes

Genotypes	Total egg number			Fertility of egg set (%)	Percentage hatchability of	
	Set	Fertile	Hatched		Eggs set	Fertile eggs
Local Kei	800	587	472	73.4	59.0	80.4
Fayoumi-crosses	600	515	442	85.8	73.7	85.8
RIR-crosses	600	483	328	80.5	54.7	67.9
Overall mean	667	528	414	79.2	62.5	78.0

RIR: Rhode Island Red chicken breed.

Hatchability of total eggs set for Fayoumi-crosses, RIR-crosses and local Kei was 73.7%, 54.7% and 59.0%, respectively while the respective hatchability of fertile eggs was 85.8%, 80.4% and 67.9% for Fayoumi-crosses, Kei and RIR-crosses (Table 1). Hatchability of total eggs set and that of fertile eggs was higher for Fayoumi-crosses and local Kei than for RIR-crosses, but the difference was insignificant (χ^2=0.102, P>0.05).

Age at sexual maturity and body weight traits

Age at first egg was significantly earlier for Fayoumi-crosses (154 days) and RIR-crosses (161 days) than for local Kei chickens (183 days, Table 2). There was no significant difference in age at first egg among F_1 crosses. Local Kei chickens were by 3 to 4 weeks delayed to reach sexual maturity as compared to both F_1 crosses.

The RIR-crosses had significantly higher body weight at all measured age points than both Fayoumi-crosses and local Kei chickens (Table 2). The Fayoumi-crosses were significantly heavier than local Kei chickens.

Egg production traits

Both F_1 crosses had significantly higher egg number on hen-day and hen-housed basis than local Kei chickens (Table 3). Hen-housed and hen-day egg production rates for the Fayoumi-crosses were significantly higher than that for the RIR-crosses. Eggs from RIR-crosses were significantly heavier than those of local Kei and Fayoumi-crosses. The egg weight of Fayoumi-crosses was not significantly heavier than that of local Kei hens. On the other hand, both F_1 crosses produced significantly higher total egg mass than local Kei chickens.

Mortality

During the brooding period, the mortality rate in RIR-crosses, Fayoumi-crosses and local Kei chickens were 6.7%, 2.5% and 3.8%, respectively (Table 4). No mortality was recorded due to predation during the brooding period. A higher mortality rate was recorded from 8 to 20 weeks of age, which was mainly caused by diseases. The mortality rate in RIR-crosses (25.9%) was significantly higher (χ^2=9.731, P<0.01) than Fayoumi-crosses (15.8%) and local Kei chickens (17.8%).

However, the mortality rate due to predation was very low during this period in the three genotypes.

Fertility and hatchability traits

The hatchability of total eggs set (54.7%) and fertile eggs (67.9%) for the RIR-crosses found in this study was comparable to those reported by Halima *et al.* (2007) for RIR breed raised under intensive management. Under farmers' management condition, Miazi *et al.* (2012) reported a fertility of 88.6% and hatchability of 86.5% for Fayoumi chicken breeds of Bangladesh, which is consistent with that of Fayoumi-crosses obtained from the present study. Sayda (2012) reported 71-80% hatchability values for local chickens of the Sudan kept under farmers' management conditions which is similar to the current results of local Kei and RIR-crosses. Consistent with the results of the current study for RIR-crosses, Rahman (2003) reported a hatchability of 71.5% for Deshi × RIR crosses under rural condition. The percentage hatchability from fertile eggs reported by Wondmeneh *et al.* (2011) for Fayoumi breed under intensive management was similar to the current results obtained from both F_1 crosses. However, the average percentages fertility and hatchability from the total eggs set reported by the same authors was higher than those of local Kei and both F_1 crosses in the current study.

The fertility of eggs from local Kei in the present study is slightly lower than that of reported by Kumar *et al.* (1976) for the crosses of White Leghorn (78.2%). These variations in fertility rate of eggs can be explained by the differences in the age of the birds, nutrition, disease and environmental factors in which experiments were conducted. Most previous studies were conducted under intensive management conditions where the housing, feeding, disease and other environmental factors are controlled. In the current study, chickens were only scavenging and other factors were not controlled which possibly could affect the full genetic expression of birds. Temperature is a major factor for the production of the fertile eggs. It has been reported that fertility is affected severely during both hot and cold weather (Crawford, 1984). Moreover, the fertility of eggs and their hatchability depends on various factors such as breed, season, pre-incubation holding period and temperature, care of hatching eggs, moisture, etc. (Silversides and Scott, 2001).

Table 2 Age at sexual maturity of pullets and body weights of the three genotypes at different growth stages (Mean±SD)

Genotypes	Age of sexual maturity (d)	Body weight (g)		
		At 24 wks	At 34 wks	At 52 wks
Local Kei	183^{a}±14.3	929^{c}±77.9	994^{c}±76.0	1021^{c}±80.1
Fayoumi-crosses	154^{b}±13.0	100^{b}±93.5	1061^{b}±92.0	1075^{b}±98.8
RIR-crosses	161^{b}±14.4	1148^{a}±102	1233^{a}±99.3	1275^{a}±95.5
Overall mean	166±13.6	1039±82.3	1096±86.1	1124±92.3

The means within the same column with at least one common letter, do not have significant difference (P>0.05).
RIR: Rhode Island Red chicken breed and SD: standard deviation.

Table 3 Average (±SD) values of egg production, egg weight and egg mass for local Kei chickens and their F_1 crosses with Fayoumi and Rhode Island Red chicken breeds

Genotypes	Egg number		Egg production rate (%)		Egg weight (g)	Total egg mass (g)
	Hen-housed	Hen-day	Hen-housed	Hen-day		
Local Kei	35.8^{b}±12.0	40.5^{c}±6.95	21.5^{c}±4.79	22.7^{c}±3.93	38.3^{b}±1.98	1371^{b}±358
Fayoumi-crosses	98.5^{a}±15.8	114^{a}±15.5	49.3^{b}±12.2	54.8^{a}±6.58	40.0^{b}±1.83	3960^{a}±855
RIR-crosses	85.2^{a}±14.3	99.8^{b}±11.7	44.2^{a}±11.5	49.2^{b}±5.70	44.2^{a}±2.94	3766^{a}±965
Overall mean	73.2±13.6	84.8±14.3	38.3±13.8	42.2±4.46	40.8±2.05	3032±223

The means within the same column with at least one common letter, do not have significant difference (P>0.05).
RIR: Rhode Island Red chicken breed and SD: standard deviation.

Table 4 The mortality rate (%) of the three genotypes at different developmental stages as caused by disease and predator

Genotypes	Brooding		Post-brooding		Adult stage	
	Disease	Predator	Disease	Predator	Disease	Predator
Local Kei	3.75^{b}	NO	17.8^{b}	2.60	4.17^{a}	8.33^{b}
Fayoumi-crosses	2.50^{b}	NO	15.8^{b}	2.14	2.08^{b}	4.17^{c}
RIR-crosses	6.67^{a}	NO	25.9^{a}	2.23	4.17^{a}	14.6^{a}
Overall mean	4.28	-	19.8	2.32	3.47	9.03

The means within the same column with at least one common letter, do not have significant difference (P>0.05).
RIR: Rhode Island Red chicken breed and NO: not observed.

Both high and very low moisture contents in the weather affect the hatchability while moderate moisture content of the air enhances better result (Cowan and Michie, 1978).

Sexual maturity of birds

Age at sexual maturity (age at first egg) improved through crossbreeding of local Kei chickens with RIR and Fayoumi chicken breeds. Similar findings on improved age at sexual maturity of F_1 crosses between local chicken ecotypes with different exotic chicken breeds were also reported (Melesse *et al.* 2005; Halima *et al.* 2007; Bekele *et al.* 2009; Bekele *et al.* 2010; Ajayi, 2010). Sexual maturity age of local Kei chickens was comparatively higher than those reported by Halima *et al.* (2007) for local chickens (157 days) and Melesse *et al.* (2011b) for Ethiopian naked-neck chickens (156 days) reared under intensive management conditions. Melesse *et al.* (2011b) reported that age at first egg was reduced on average by 6 days in F_1 crosses as compared with exotic commercial chicken breeds (Lohmann white and Newhampshire).

The average age at first egg of both F_1 crosses (Fayoumi×Naked neck chicken and RIR×local Netch) reported by Bekele *et al.* (2010) was 197 days which was longer than observed for both F_1 crosses in the current study. The differences in attaining sexual maturity might be due to the genetic differences of strains involved in the crossbreeding scheme.

Age at first egg can also be influenced by many environmental factors, such as temperature, nutrition and day length as suggested by Melesse *et al.* (2011b) and Zaman *et al.* (2004).

This indicates that sexual maturity depends on the physiological age of the animal and if this process is delayed due to various factors such as poor nutrition, disease, etc., it will be reflected in the later start of egg laying period.

Body weight of birds

The RIR-crosses had higher body weight at all measured age points than both Fayoumi-crosses and local Kei chickens. These findings are consistent with those of Zaman *et al.* (2004) who reported higher body weight for RIR-crosses than Fayoumi-crosses under semi-scavenging condition in Bangladesh.

The higher body weight observed in RIR-crosses might be attributed to the genetic superiority of the RIR breed in body weight which is a highly heritable trait and known for its non-additive genetic response to crossbreeding (Rahman *et al.* 2004; Bekele *et al.* 2010).

Melesse *et al.* (2011a) reported 952 g body weight of Ethiopian female naked-neck chicken at the age of sexual maturity under intensive management system, which is comparable to the current findings for local Kei chickens (924 g) of the same age.

The same authors reported an average body weight of 1169 g at sexual maturity age for F_1 crosses of Ethiopian naked-neck and Lohmann White chicken breed that is comparable to the body weight of RIR-crosses (1132 g) at similar age.

Egg production traits

The observed hen-housed egg production for local chickens in the present study was comparable to that reported by Sazzad (1992) for indigenous Desi breed under traditional rural system. However, the hen-housed egg production obtained from RIR-crosses in the present study was higher than that reported by Sazzad (1992) for RIR breeds under traditional rural system.

The hen-housed egg production reported by Bekele *et al.* (2010) for F_1 crosses under traditional system was lower than the results obtained from the present study. The reason for improved egg production for the F_1 crosses in the present study might be explained by the early maturity of genotypes used in the current study that enabled them to produce higher number of eggs. Egg production of F_1 crosses were higher than those local chickens reared under farmers' management conditions similar to the findings of Bekele *et al.* (2009).

In another study conducted by Melesse *et al.* (2011b) under intensive management, the Ethiopian naked-neck chickens produced 39.2% hen-housed egg production, which is comparable to that of RIR-crosses but higher than that of the local Kei chickens. The hen-housed egg production for the local Kei chickens found in the current study was relatively lower than that of reported for local ecotypes of chicken by Halima (2007) under intensive management condition.

These variations in performance could be attributed to the traditional rural system (Bekele *et al.* 2009; Bekele *et al.* 2010; Miazi *et al.* 2012) which might have not allowed the full genetic expression of RIR and their F_1 crosses. The average egg weight (38.3 g) found for local Kei chickens in the current study was higher than reported by Ajayi (2010) for Nigerian indigenous chicken populations under scavenging conditions. Interestingly, the average egg weight (41 g) reported by Ajayi (2010) was similar for crosses between White Leghorn and Nigerian Indigenous chickens with that of Fayoumi-crosses (40 g) of the current study.

CONCLUSION

The overall results of the present study revealed that the F_1 crosses showed better egg production potential as compared to that of local Kei chickens. Although RIR-crosses were heavier in body weight, the Fayoumi-crosses were superior in egg production traits with low mortality compared with both genotypes. Thus, using Fayoumi chicken breeds, as a strategy for upgrading the egg production potential of indigenous chickens under farmers' management condition could be a better breeding strategy along with improved feeding, housing and health care extension packages.

ACKNOWLEDGEMENT

The authors would like to thank Operational Research Project, funded by the Irish Government through Irish Aid Programme for funding support and all farmers in Beresa watershed district of Southern Ethiopia who actively participated in this project.

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