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Genetic evaluation of breeding program for body weight of indigenous chicken in Kenya

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Abstract

The demand for poultry meat, particularly from indigenous chicken, is ever increasing. This need efficient production potential from the chicken. This paper simulated different scenarios of breeding program for indigenous chicken and compared the selection response with realized genetic gain after one generation of selection. A one stage discrete generation deterministic simulation approach using SelAction program was used. Two genetic parameters were employed. The phenotypic variances and heritability used were 25,000g and 0.25, 3040 and 0.51, respectively. For each case, 300 hens and 50 cocks were selected to produce the next generation. Each cock was mated to 6 hens and each hen produced 6 offspring. The best 50% and 20% of females and males, respectively, were selected for mating. The expected selection response was simulated as follows; a) own performance b) own performance, full sibs and half sibs and c) own performance with full sibs, half sibs and BLUP information sources. A sire model of BLUP was used for realized selection response. The predicted genetic gain for all simulated programs were much lower than realized response. This realized genetic gain could only be achieved by higher selection intensity on cocks, however this would increase the inbreeding rate above recommended level. The breeding program has shown potential for improvement and success in body weight at 12 weeks of age.

Keywords: Indigenous chicken, Kenya, selection response, simulation, realized response

Introduction

The estimated poultry population in Kenya is 57 674 965 birds of which indigenous chicken (IC) are 80%, broilers 8.5% and layers 9.4%. Other types of poultry reared in smaller numbers but gaining importance include ducks, quails, turkeys, ostriches, and guinea fowls making up 2.1 % of the total poultry population (SDL, 2020). The rural poultry system is dominated by indigenous chickens and has made significant contribution to poverty alleviation and household food security in many developing countries (Khobondo et al., 2015). Among the poultry breeds, indigenous chicken are the predominant type in almost all households (KNBS, 2010). Indigenous chicken are not as high productive if kept under optimal conditions, but are well adapted to the more harsh conditions of the rural poultry system (Ajayi, 2010). Comparative analysis with their modern counterpart's shows indigenous chicken are generally poor producers of eggs and meat (Wondmeneh et al., 2014). Consequently, they are/were being replaced by commercial strains in many developing countries or improvements strategies have involved cross breeding (Khobondo et al., 2015). In some countries the cross-breeding strategy was pursued for decades to increase productivity under village systems but failed to bring sustainable improvement (Dana, et al., 2010). It also posed a serious threat to the existing genetic diversity of indigenous chickens (Besbes, 2009). Despite their low genetic potential in production, for example, their low growth rates and egg production, IC are generally better in disease resistance and could maintain higher level of performance under poor nutrition and high environmental temperatures compared to commercial strains under village systems (Psifidi et al., 2016). There are indications that indigenous chickens are better capable of dealing with infection pressure as well (Khobondo et al., 2014). With this positive attributes, indigenous chicken seemed the ideal starting material to increase production level, while maintaining the resilience to sub-optimal circumstances such as food of irregular quality and quantity. Hence the need for genetic improvement witnessed in Ethiopia and Kenya.

A breeding program was initiated at Egerton University indigenous chicken breeding center in Kenya. The starting generation consisted of chicks that were hatched from eggs collected from various locations (ecotypes) in Kenya. The breeding objectives were defined using different participatory approaches from IC keeping communities. The breeding goals were determined based on questionnaires, personal interviews and focal group discussion with smallholder farmers, marketers and consumers in a number of regions in Kenya (Psifidi et al., 2016). The study identified egg number, growth rate, body size, fertility, disease resistance, meat quality, egg size, eggshell color, broodiness and mothering ability to be traits of economic importance. Growth rate was ranked the most important trait for meat type IC (Lwelamira et al., 2010) hence the effort to improve the trait genetically. Genetic studies require estimation of genetic parameters like heritabilities, correlation and variation. Studies on biodiversity of indigenous chickens in many parts of Africa revealed the presence of high genetic variability within than between ecotype populations (Khobondo et al., 2014) indicating the potential for genetic improvement through selective breeding. Breeding goal in indigenous chicken entails among other components, determination of traits of economic importance. In Kenya, weight gain was rated among the most important traits (Psifidi et al., 2016). The aim of this study was to optimize the breeding program by deterministic simulations, evaluate current breeding program after one generation and compare the realized selection response with expected deterministic simulated responses.

Materials and methods

Description of on-station

This study was carried out on-station. The on-station experiments were carried out at the poultry breeding and Research Unit at Egerton, Kenya. This station at the University lies at 0°22'S 35°56'E coordinates. Administratively, it lies in Nakuru County. The study area has an annual rainfall of about 1250 mm and annual temperature range of 16-29 °C. The altitude of the station is 2267 m above sea level.

Chicken flock management

Chicken eggs were collected from different ecotypes of Kenya as explained elsewhere (Khobondo *et al*., 2014). Collected eggs were artificially incubated from this population to form the base population (Generation 0). From the hatched eggs, all chicks were checked for deformity, vaccinated (against Marek's at the hatchery, Newcastle at Day 1 and 21, Gumboro at day 7, Fowl pox in week 10 and Fowl Typhoid in week 14), wing tagged, weighed and randomly assigned into pens of concrete floor filled with bedding material. Starters were provided with a chick feed (20% CP and 2,950 kcal/kg) until 8 weeks of age, and grower feed (18% CP and 2,850 kcal/kg) from 8 to 20 weeks. From 20 weeks onwards all female birds were provided with ad libitum layer feed (16% CP and 2,750 kcal/kg). The chickens were kept in an open house in deep litter system with concrete floor filled with wood shavings until 20 weeks of age under a standard housing space, with natural lighting after 8 weeks of age.

Traits recorded

On all growing birds, data on body weight (individual, weekly), cumulative feed intake (pen, weekly), and survival (individual, week 20) were recorded, and feed conversion ratio (pen, weekly) was calculated. Data were summarized at weekly basis, on all chickens in a pen during the growing period (0-20 weeks) on station. For this study, body weight at week 12 (BW12) was selected based on high heritability and correlation with other body weights (Magothe *et al*., 2010).

Expected deterministic Simulation conditions

A deterministic simulation approach using SelAction program (Rutten, 2002) was used to determine the selection response and inbreeding rate using the one stage discrete generation**.** The phenotypic variances and heritability used were 25,000g and 0.25 respectively as estimated elsewhere (Dana et al 2011) here called simulation 1. For comparison, phenotypic variances and heritability of 3040g and 0.51, respectively, were used (Muasya *et al*., 2015) henceforth called simulation 2. In each generation, 300 hens and 50 cocks were selected based on weight at week 12 (BW12) to produce the next generation. Each cock was mated to 6 hens and each hen produced 6 offspring (3 males and 3 females). Truncation selection in males and females was performed and the best 50% of females (450 out of 900) were used as hens for the next generation and the best 20% of males (180 out of 900) were used as cocks for the next generation. The expected selection response was determined by each simulation as follows; a) own performance (SX;1) b) own performance, full sibs and half sibs (SX;2) and c) own performance with full sibs, half sibs and BLUP (SX;3) information sources. Where SX is either simulation 1 or simulation 2. SX4 was SX2 (phenotypic variances and heritability of 3040g and 0.51, respectively) with intense cock selection of 0.01 instead of 0.02.

Realized selection response

Significant effects (sex, cluster, generation) and covariates for subsequent genetic analyses were determined using SAS package (SAS, 2004). Variance-covariance components were estimated and estimated breeding values (EBVs) were calculated using MTDFREML software (Boldman, 1993) fitting univariate sire model. BW0 was fitted as a covariate in the analysis of BW12. Other fixed effects included generation, sex of bird and cluster. The model used in matrix notation was as follows:

$$y = Xb + Zs + e$$

Where y is a vector of observations; X and Z are known incidence matrices relating records to fixed and random sire effects, respectively; b is a vector of fixed effects (generation, sex and cluster) and covariates; s is a vector of random sire effects; while e is a vector of residuals.

Results

Expected response to selection

The results for expected genetic gain are summarized in Table 1.

Table 1. The response to selection at BW12 of the two simulated programs and realized genetic gain.

		Response to selection								
		Simulation 1				**Simulation 2**				**Realized**
Scheme/information source		**M**	**F**	**T**	**IR**	**M**	**F**	**T**	**IR**	**T**
	1	24.25	13.83	38.10	0.33	15.95	9.10	25.15	0.35	-
	2	28.14	16.05	44.19	0.56	16.63	9.48	26.11	0.45	-
SX	**3**	28.53	16.27	44.80	0.55	16.72	9.53	26.27	0.45	**67.50**
	4	52.10	15.83	**67.93**	1.37	30.89	9.34	40.23	0.81	-

M= Male, F= Female, T = Total, IR = Inbreeding rate

There was observed increase in response to selection in simulation 1 model with addition of information sources (Figure 1).

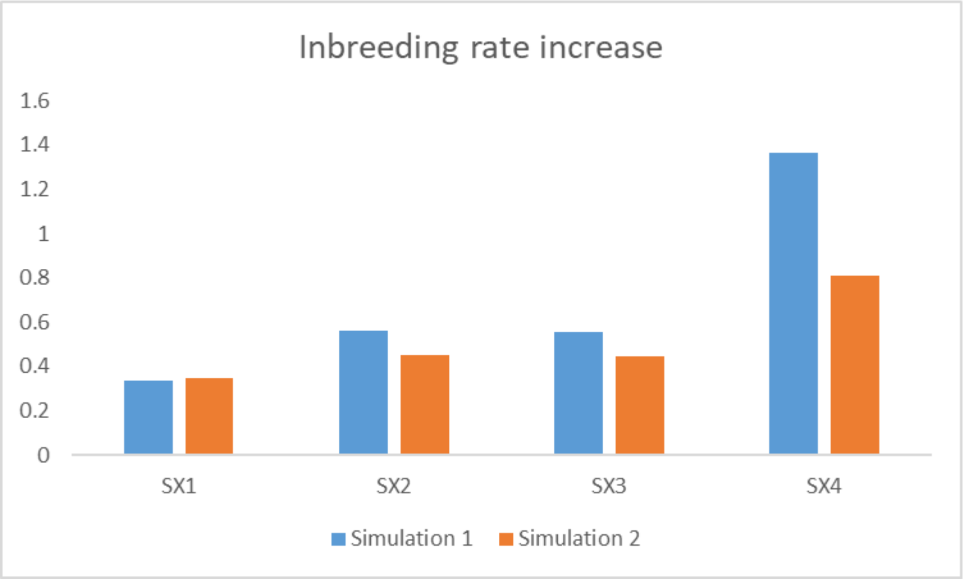

Figure 1: Showing the increase of Inbreeding rate with addition of information sources

The own performance (OP) alone gave the lowest genetic gain (38.089 g) as compared to OP, HS, FS (44.192 g) (Table 1). However, it was noted that addition of information sources increased the inbreeding rate from 0.335 to 0.553, respectively. The same increase in inbreeding rate was noted for simulation 2 as well (Figure 1).

The selection response using simulation 2 mimicked the results from simulation 1. However, the result/gain was relatively lower as compared to simulation 1 results/estimates (Figure 2). For example, a genetic gain of 44.796g as compared to 26.252g for OP, HS, FS, and BLUP program was predicted, respectively (Figure 2).

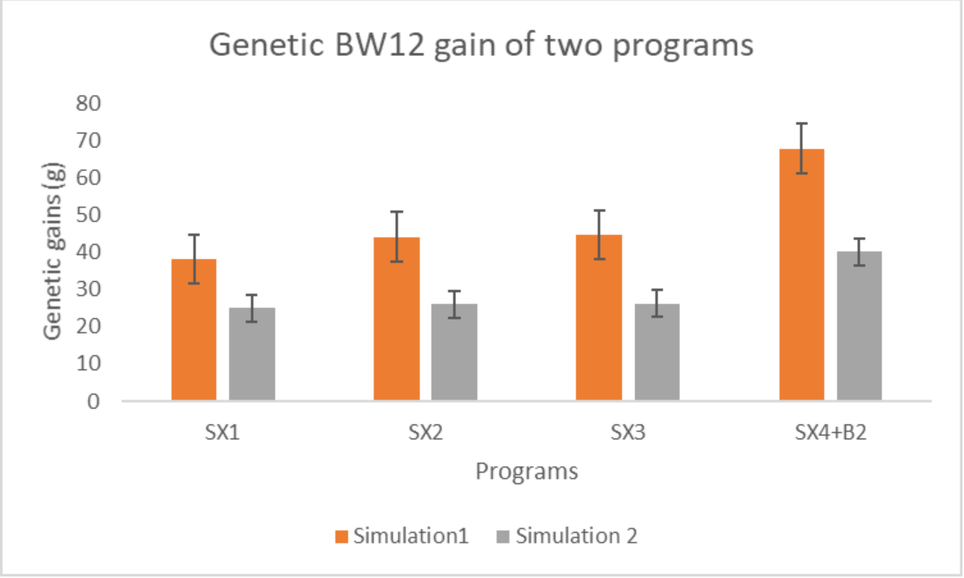

Figure 2: Showing the increase of response to selection with addition of information sources

The predicted genetic gain for both simulated programs was much lower than realized response to selection at BW12 (26.2 g and 44.7 g vs 65.7 g) (Figure 3).

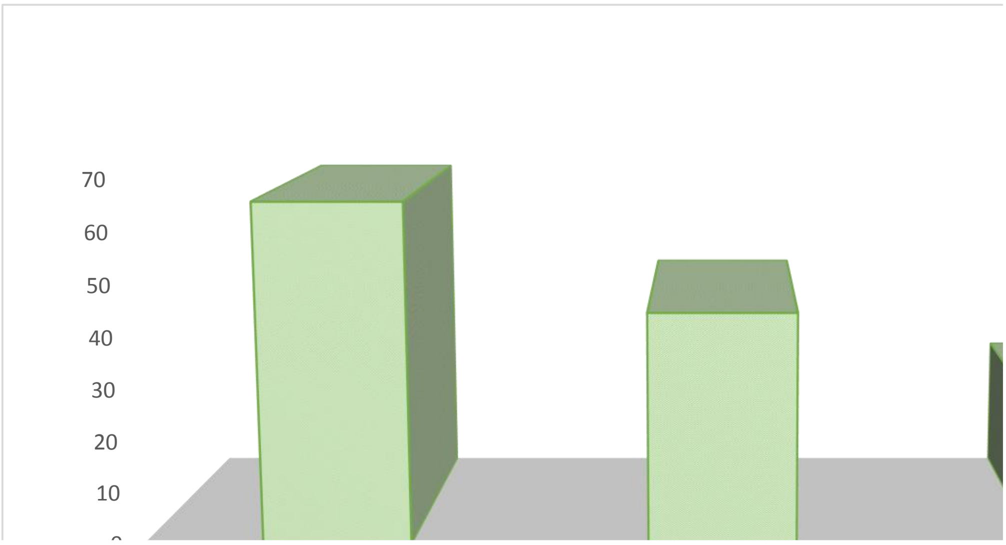

Figure 3: The realized genetic gain was higher than the two simulated programs

The realized genetic gain could only be achieved by higher selection intensity on cocks (10%), however this would increase the inbreeding rate to 1.4%, a levels higher than FAO recommendations.

Realized response to selection

Body weight at 12 weeks of age (BW12) for males and females are given in Table 2. The results confirm that sexual dimorphism exists for body weight in indigenous chicken. Males were significantly (P<0.05) heavier than females. The average BW12 for males in G0 was 595.1 g, this was slightly lower than 662.6 g for males at G1. For females the average body weight was 550.1 and 574.3 g for G0 and G1, respectively (Table 2). The response to selection was 77 and 24.2 g for males and females, respectively.

Table 2: Response to selection for body weight (g) at 12 weeks in Kenyan indigenous chicken

	Realized Body weight (g)		
	Male	**Female**	**Total**
G0	666.7	550.1	595.1
G1	743.7	574.3	662.6
Response to selection	77.0	24.3	**67.5**

G0 = first generation; G1 = second Generation

In comparison to both simulation programs, the realized selection response were much higher at BW12 (26.2 g and 44.7g vs 65.7 g) (Figure 3). The realized selection response (67.5 g) could only be achieved by higher selection intensity on cocks (10%), however this would increase the inbreeding rate to 1.4% (Table 1) a levels higher than FAO recommendations.

Discussion

The importance of indigenous chickens in developing countries has been demonstrated in many literatures. These countries are dominated by complex, diverse and risk-prone rural livelihoods, and considering this context, smallholders in developing economies need breeds that are flexible and resistant to the prevailing environment (Psifidi *et al*., 2016). Developing countries, therefore, can opt to improve their IC performance or develop their own breeds suitable for prevailing production circumstances. In the smallholder production environment, chickens frequently experience feed scarcity, disease challenges and stress. Considering these production circumstances, a tailor-made breeding program is needed to ensure that genetic improvement is achieved. Therefore, the need to define a breeding goal that considers both production and adaptive traits has been emphasized (Psifidi *et al*., 2016). Genetic improvement in IC may be generated on a single nucleus farm as the one in Indigenous Chicken Improvement Programme (InCIP). Indigenous chickens can be genetically improved using within-breed selection (Wondmeneh *et al*., 2014). It was worth doing a simulated study of different schemes to find out the most opt scheme for implementation. In this study three different schemes were simulated using different genetic parameters estimates.

The result showed a scheme with own performance, full sibs, half sibs and BLUP (SX;3) information sources to be the most efficient as compared to others (own performance, full sibs and half sibs (SX;2) and own performance (SX;1), respectively). This showed that with more sources of information, the accuracy of selection index was improved hence the best birds could selected to be parents of the next generation. Such scheme (with more sources of information) however had an increase in inbreeding rate as noted in this study due to maximized co-selection of siblings. Despite being the scheme with high genetic response, there was increased inbreeding rate that would lead to increased homozygosity within the population resulting in reduced genetic variance, inbreeding depression and lethal genes resurgence. In such cases, methodologies should be developed to incorporate populations with overlapping generations especially if the population of study is small (Sonesson and Meuwissen, 2001). Alongside inbreeding and selection response, cost factors must be considered before choosing the best scheme. Although, the SX3 scheme had the highest selection response, the cost of implementation may be the most expensive. In developing world Kenya included, implementation of a high cost breeding program may be a challenge (Psifidi *et al*., 2016). Therefore informed intuitive decision based on scientific literature and economic may be logical. Mass selection (own performance) on body weight although had the lowest selection response could be scheme of choice due to low cost and low inbreeding rate. The scheme and selection criterion has been practised in Ethiopia and found to be successful (Wondmeneh *et al*., 2014). That on-station study involved comparison of improved chickens with indigenous both during the growing and laying period. All the traits measured indicated that the improved chickens were superior to their indigenous type.

In this study, the realized response to selection in BW12 in both sexes was positive and higher in males than in females. The results confirm that sexual dimorphism exists for body weight in indigenous chicken. The BW12 for males in Generation 0 is similar to that reported for the same population (Magothe *et al.*, 2010). In that study, males in G1 had a mean BW12 higher than the weight reported by Magothe *et al.* (2010) for the same population, indicating it was possible to improve body weight in indigenous chicken through selection (Magothe *et al*., 2010). On average weight of males and females in G1 were higher than those in G0, indicating an upward trend in BW12. However, the females had lower genetic gain as compared to males. The lower and higher genetic changes among females and males could be attributed to lower and higher selection intensity, respectively. Also, most of the females were retained for further evaluation of egg production. Earlier, it was reported that within ecotype selection can successfully bring about genetic improvement within some generations (Lwelamira *et al.,* 2008). A study reported a genetic trend of 4.78 for BW12 in Mazandaran native chicken of Nothern Iran (Niknafs *et al* ., 2013). Another study reported an increase of BW11 from 924.70g ±206.84 g to 1443.64 g±145.79 g in males and from 766.51 g ±176.99 g to 1128.99 g (±106.26 g) in females of Ardennaise chicken breed after three selection cycles (Larivière *et al*., 2009). In Horro chicken breeding program in Ethiopia, a positive genetic trend was observed on BW16 from G4 to G6 (Wondmeneh *et al* ., 2014). Despite the Horro results, the improved chickens were still lower in performance compared to crossbred and the commercial lines. This positive trend was expected in this breeding program as well.

The realized genetic gain was much higher than the simulated schemes. The deviation of the realized response from the predicted response was an attribute of the prediction error. The higher realized genetic gain could be due genetic and/or environmental errors. For environmental component, the on-station management represented an improved village chicken system in which production system employ the use of better housing, feeding and health management. The enhanced management could imply high expression of genetic potential hence the higher selection response. The genetic reasons could span about error (under) in the estimation of genetic parameters in simulation. The heritability and variance estimates of BW12 used in simulations could be lower than real heritability and phenotypic variances, respectively, exhibited by IC in Kenya. The other reason could be high selection intensity of males as exhibited on the realized program at InCIP, this might led to high genetic gain as a result of high selection intensity. The alternative reason could be failure to account for environmental systemic effects affecting variation on BW12 during the genetic parameter estimation. The program at InCIP employed the use of BLUP which due to animal relatedness increase inbreeding, it important that subsequent mating need to consider coancestries among mates to avoid build-up of inbreeding in this population.

Conclusion

The breeding program of indigenous chickens has shown potential for genetic improvement and success in body weight at 12 weeks of age. The weight at week 12 could therefore be improved by selection of both female and male chicken.

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Statement of interest

No conflict of interest

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