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Genetic and Economic Evaluation of Alternative Breeding Objectives for Adoption in the Smallholder Indigenous Chicken Improvement Program

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Introduction

The indigenous chicken (IC) production has been globally recognised as a strategy to wealth creation, poverty, and malnutrition and hunger reduction among the resource poor rural households in the developing countries. This has been attributed to their requirement for small investment, short production cycles, scavenging ability and greater adaptability to harsh environmental conditions (Besbes 2009). Although they are present whenever there are human settlements, their low productivity has hindered their potential to uplift the living standards of their custodians and contribute to rural development. Previous efforts to improve their productivity through crossbreeding with commercial exotic breeds have been unsuccessful due to incompatibility of crossbreds with low-input production systems, lack of clear breeding objectives and operational breeding programs to ensure constant supply of breeding stock to farmers (Ngeno 2011). Their genetic improvement should therefore focus on within breed selection to maintain their unique attributes appreciated by producers and consumers and promote their conservation by utilization. This study therefore, aims at identifying the optimal within IC selection scheme based on their genetic and economic worth by evaluating farmers and alternative breeding objectives for adoption in the IC breeding program.

Material and Methods

A three-tier closed nucleus breeding program using non-progeny tested cocks and hens to produce chicks in the lower tiers was considered. The breeding program has the nucleus, multiplier and commercial units. The nucleus is responsible for screening and recruitment of the initial breeding flock from farmers, carrying out performance and pedigree recording, genetic evaluations, selection, development of pure lines and grandparent flock. The multiplier purchases parent stocks from the nucleus, multiply them and produce crossbreds sold commercial unit for breeding or production depending on the scheme considered. Both cockles and pullets were used to transfer superior genes from the nucleus to the lower tiers. The selection groups considered were; nucleus, cocks in the nucleus to breed cocks (♂♂) and hens (♂♀), and hens in the nucleus to breed cocks (♀♂) and hens (♀♀); multiplier, cocks from nucleus to breed cocks (♂♂$_{m}$) and hens (♂♀$_{m}$), hens from the nucleus to breed cocks (♀♂$_{m}$) and hens (♀♀$_{m}$), cocks from breed A in the nucleus to breed F1 (♂$_{F1}$), hens of breed B from the nucleus to breed F1 (♀$_{F1}$) and cocks of

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breed C from the nucleus to breed hybrid (♂$_{Hy}$) and F1 hens to produce hybrid (F1$_{Hy}$) in the multiplier; and commercial, cocks from the multiplier to breed cocks (♂$_{m}$♂$_{c}$) and hens (♂$_{m}$♀$_{c}$), hens from the multiplier to breed cocks (♀$_{m}$♂$_{c}$) and hens (♀$_{m}$♀$_{c}$), cocks in the commercial to breed cocks (♂$_{c}$♂$_{c}$) and hens (♂$_{c}$♀$_{c}$) and hens in the commercial to breed hens (♀$_{c}$♀$_{c}$). The Hy from the multiplier were also raised as terminal breeds in the commercial unit for eggs and meat production.

Three breeding objectives based on marketable end products were considered in this study. They included dual-purpose IC (ICD), representing the IC bred for both egg and meat production, simulating farmers' preference (Okeno et al. 2012b), IC layers (ICL) and IC broilers (ICB), depicting alternative breeding objectives for IC lines selected for egg and meat production, respectively. The breeding objective traits considered in ICD were egg number (EN) from 24 to 50 weeks, egg weight (EW), daily gain (ADG), live weight at 16 weeks (LW), age at first egg (AFE), fertility (FER), hatchability (HA), faecal egg count (FEC), immune antibody response (Ab) and feed intake (FI). Daily gain and LW were not considered in the ICL, but they were the main focus in ICB. Each breeding objective was evaluated under two selection schemes; pure line selection (PLS) representing pure line selection for eggs and meat production and crossbreeding selection (CBS) representing a three-way crossbreeding strategy to produce hybrids for dual-purpose, eggs or meat production. Selection was only considered within the nucleus and the criteria used were based on the traits which are currently being recorded in the breeding stations in Kenya. These traits included EN, EW, LW, HA and AFE. The information sources for selection groups included performance records from individuals, sire, dam, full sibs (dam family), half sibs (sire family), female and male half sibs of the sire and dam. The ZPLAN computer programme (Willam et al. 2008) was used to model and evaluate the breeding program for IC in the current study. This program uses population, biological, technical and economic parameters to compute response to selection for single trait, annual genetic gains for breeding objective traits and annual returns on investment per hen using deterministic approach. The population, biological, economic and technical parameters assumed to evaluate the breeding program were obtained from on-farm and on-station experiments conducted in Kenya (Ngeno 2011; Okeno et al. 2012a). A flock size of 48000 hens with 1, 29 and 70 % being in the nucleus, multiplier and commercial units, respectively, with mating ratio of 1:5 was considered. The genetic and phenotypic parameters for traits in the breeding objective were obtained from studies that evaluated the performance records of IC raised intensively in Kenya (Ngeno 2011), while their risk-rated economic values were estimated using bio-economic model and selection index methodology (Okeno et al. 2012b). The costs and returns were discounted at 4 and 6 %, respectively and an investment period of 20 years assumed.

Results and Discussion

The genetic responses to selection for individual traits in the three breeding objectives and two selection schemes after one round of selection are presented in Table 1. Generally, there were differences in genetic gain per trait between the three breeding objectives and selection schemes. The genetic gains per trait were high in PLS compared to CBS. For example, in ICD the genetic gain for EN, EW, ADG and LW under PLS were 1.36 eggs, 0.53 g, 0.94 g and 38.72 g, respectively, compared to their corresponding gains of 1.10 eggs, 0.39 g, 0.93 g and 20.35 g in CBS. Similar trend was observed in the ICL and ICB except for EW, LW and EN which had higher and positive genetic gains under CBS than PLS which had negative gains. The high genetic gains observed under PLS compared to CBS is an indication that pure line selection would lead to faster genetic gains than crossbreeding schemes. This is consistent with previous studies which have compared the two selections schemes (Adeleke et al. 2011).

Table 1 Genetic gains for single trait in the indigenous chicken dual-purpose (ICD), layer (ICL) and broiler (ICB) breeding objectives under pure line and crossbreeding selection schemes

Traits	Selection schemes					
	Pure line			Crossbreeding		
	ICD	ICL	ICB	ICD	ICL	ICB
Egg number	1.36	2.71	-1.99	1.10	1.79	1.06
Egg weight	0.56	-0.52	0.77	0.39	0.87	0.60
Daily weight gain	0.94	-0.03	1.79	0.93	0.13	0.79
Live weight	38.72	-4.40	57.96	20.35	9.90	26.18
Fertility	1.23	1.88	-0.05	0.07	1.54	0.04
Hatchability	1.53	2.09	-0.14	0.49	2.15	0.02
Age at first egg	-1.77	-2.46	-0.67	-1.03	-1.52	-1.10
Faecal egg count	-0.14	-0.12	-0.09	-0.53	-0.49	-0.36
Antibody response	-0.16	-0.07	-0.11	0.13	0.10	0.09
Feed intake	0.19	0.12	0.15	-0.01	-0.01	-0.01

The high genetic gains for EN (2.71 eggs) in ICL and ADG (1.79 g) and LW (57.96 g) in ICB compared to their respective values of 1.36 eggs, 0.56 g and 38.72 g in ICD, is an indicator that adoption of alternative breeding objectives (ICL and ICB) in the breeding program would result to faster genetic gains compared to the farmers breeding objective (ICD). However, there would also be a need to consider CBS since intense selection for EN and LW in PLS resulted to reduced disease resistance (Ab) and increased FI (Table 1). The genetic progress for EN and LW obtained in the current study were within the range of 2.45-3.10 eggs and 45-89 g reported for commercial layers, broilers and Kuchi IC ecotypes (Zerehdaran et al. 2009; Lwelamira & Kifaro 2010).

The monetary gains, returns to selection and profitability per hen obtained in this study under the two breeding schemes (Table 2) followed similar pattern as was observed under genetic gains for individual traits (Table 1). The PLS had the highest monetary gains, return to selection and profitability. ICB was the most profitable breeding objective (KSh3232.71), followed by ICD (KSh1668.14) and ICL (KSh1251.14) in PLS, while their corresponding values in CBS were KSh1200.42, 1062.72 and 966.87. These findings agreement with previous studies which have reported high profitability under pure breeding than crossbreeding programs (Ilatsia et al. 2011).

Table 2 Genetic gains, returns to selection, total costs and profitability (KSh, US$1 = KSh80.00) per hen after one round of selection in the indigenous chicken dual-purpose (ICD), layer (ICL) and broiler (ICB) breeding objectives under the pure line and crossbreeding selection schemes

Selection schemes	Breeding objectives	Monetary gain/year (KSh)	Returns/hen (KSh)	Costs (KSh)	Profit/hen (KSh)
Pure line	ICD	214.28	2047.22	379.08	1668.14
	ICL	186.11	1630.88	379.08	1251.80
	ICB	372.60	3611.79	379.08	3232.71
Crossbreeding	ICD	143.37	1190.70	127.98	1062.72
	ICL	116.64	1094.45	127.98	966.87
	ICB	162.00	1328.40	127.98	1200.42

The comparisons between the three breeding objectives indicate that it would genetically and economically rewarding to adopt ICB compared to ICD and ICL (Table 2) in IC breeding program. The superiority of ICB could be explained by the influence of high genetic gains for the growth traits (ADG and LW). The high profitability obtained in ICB is an indication that farmers who can provide optimal management would benefit more when IC is improved for meat production. The fact that LW contributed over 58.93% of the returns to selection under ICD is a confirmation that improving IC for meat production by adopting ICB in the breeding program would be more profitable. It should, however, be noted that breeding program ignoring the wishes of smallholder farmers who own majority of IC would be detrimental. Therefore, there would be a need to strike a balance between production, reproduction and adaptability traits to develop a breed that can not only survive and reproduce under low management production conditions, but can also produce slightly more eggs and meat. This could be achieved by adoption ICB in the CBS because, this scheme has demonstrated the possibility of attaining a dual-purpose breed with moderate body weight gain, reduced feed intake and resistance to disease compared to the one developed through PLS.

Conclusions

The current study has demonstrated that there is possibility of improving IC either for dual-purpose or specialised lines for eggs and meat production. Selecting IC for meat production was the most profitable breeding objectives under optimal management regimes. However, to develop a dual-purpose breed that can fit within the smallholder farms which have sub-optimal production systems, there would be a need to develop different pure lines and then cross them to exploit heterosis on both productive, reproductive and adaptability traits as demonstrated in ICB in under CBS. On the other hand breeding programs targeting commercialization of IC should initially adopt ICL and ICB under PLS and once the desired gains have been achieved then crossbreeding strategies can be adopted for hybrids production purposes.

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