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ORIGINAL RESEARCH

Characterization of indigenous chicken production systems in Kenya

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Abstract Indigenous chicken (IC) and their production systems were characterized to understand how the whole system operates for purposes of identifying threats and opportunities for holistic improvement. A survey involving 594 households was conducted in six counties with the highest population of IC in Kenya using structured questionnaires. Data on IC farmers' management practices were collected and analysed and inbreeding levels calculated based on the effective population size. Indigenous chicken were ranked highest as a source of livestock income by households in medium- to high-potential agricultural areas, but trailed goats in arid and semi-arid areas. The production system practised was mainly low-input and small-scale free range, with mean flock size of 22.40 chickens per household. The mean effective population size was 16.02, translating to high levels of inbreeding (3.12%). Provision for food and cash income were the main reasons for raising IC, whilst high mortality due to diseases, poor nutrition, housing and marketing channels were the major constraints faced by farmers. Management strategies targeting improved healthcare, nutrition and housing require urgent mitigation measures, whilst rural access road network needs to be developed for ease of market accessibility. Sustainable genetic improvement programmes that account for farmers' multiple objectives, market requirements and the production circumstances should be developed for a full realization of IC productivity.

Keywords Characterization · Indigenous chicken · Production systems

Abbreviations

IC	Indigenous chicken
ASALs	Arid and semi-arid areas

Introduction

Indigenous chicken (IC) production is common in rural resource poor households in developing countries. They play a vital role in the human livelihoods and contribute significantly to food security of the rural communities (Hailemariam et al. 2010). Despite their importance, their low productivity has limited their potential to uplift the living standards of the farmers and contribute significantly to rural developments. In Kenya, like other developing countries, attempts to improve the productivity of IC through crossbreeding with exotic breeds were not successful (Dana et al. 2010; Olwande et al. 2010). In fact, such attempts resulted in new challenges such as increased costs of production as the resultant crossbreds were not adapted to scavenging conditions, high mortalities and erosion of IC genetic resources. These challenges are attributed to the dissemination of inappropriate technologies due to poor understanding of production circumstances under which IC are raised and the lack of information on consumer preferences and market dynamics.

Characterization of production systems is the first step to be undertaken for the purpose of identifying threats and

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opportunities for holistic improvement (Mtileni et al. 2009; Danda et al. 2010). It helps in understanding the production and management practices of farmers and the associated factors which are essential in developing improvement strategies. Characterization studies should be conducted under on-farm conditions through baseline data collection rather than on-station experimental studies (Abdelqader et al. 2007). In Kenya, such studies are limited. This study therefore aimed at characterizing the IC production circumstances by assessing the farmers', farms' and the IC management characteristics with a view of providing information to develop improvement strategies.

Materials and methods

Study sites

The study was carried out in Siaya (0°14′ N, 34°16′ E), Kakamega (0°17′ N, 34°45′ E), Turkana (3°24′ N, 35°12′ E), West Pokot (1°14′ N, 35°7′ E), Bomet (0°46′ S, 35°21′ E) and Narok (1°5′ S, 35°52′ E) administrative counties of Kenya. These counties have the highest populations of IC raised in rural households (MOLD 2010). Kakamega, Siaya, Narok and Bomet counties are classified as medium- to high-potential agricultural regions, whilst West Pokot and Turkana are arid and semi-arid areas (ASALs) (Danda et al. 2010; MOLD 2010). In each county, three divisions with three locations within each division were chosen for the survey.

Scope of the survey

Qualitative and quantitative research approaches were employed in this study. Qualitative data were obtained through group discussions with farmers and observations made by enumerators and researchers, whilst quantitative data were obtained by interviews. A pretested structured questionnaire was used to gather information. During previsits, local numerators were recruited in each division and trained by the researchers and the representatives from the Ministry of Livestock Development. Local enumerators were employed for ease of acceptability and communication within the communities. The objectives of the survey and the benefits were explained to the farmers during visits. The households in villages with the highest number of IC in each location were recorded. Simple random sampling procedure was used to select households for interviews by randomly picking 11 names of the households from the list. A total of 98, 122, 99, 96, 87 and 92 respondents were interviewed in Siaya, Kakamega, Bomet, Narok, West Pokot and Turkana counties, respectively.

Data collection and analysis

Data were collected through direct observations and interviews with farmers. Information on farmers', farms' and the IC management characteristics were collected. The farmers' characteristics included age, level of education, occupation, gender and household size. The farms' characteristics were farm size, land ownership, livestock species, number and reasons for keeping them. The IC management characteristics were nutrition, health, production systems, housing, extension services and constraints to IC production.

Data were analysed using the general linear model procedure of SAS (SAS 2000). The PROC FREQ and PROC MEANS procedures were used to carry out the frequency analysis and descriptive statistics, respectively. A non-parametric Kruskal–Wallis test (NPAR1 WAY) procedure of SAS was used to calculate the mean ranks and determine the influence of counties on livestock species kept, reasons for keeping IC and the constraints faced by farmers. This test generates mean ranks whose significance is tested using chi-square (χ^2). The effect of the counties on the different variables was estimated using the model below:

$$Y_{ijk} = \mu + c_i + g_j + \varepsilon_{ijk} \quad (1)$$

where Y_{ijk} is the dependent variable, μ the overall population mean, c_i the county effects (i=Siaya, Kakamega, Bomet, Narok, West Pokot and Turkana), g_j the gender of the household head effect (j=male or female) and ε_{ijk} the random residual effect.

The flocks in each village in the six counties were considered as different breeding populations. This was because the villages were far from each other and separated by rivers, valleys and hills, and therefore only flocks from the same village could scavenge together and mate freely. Since there is no controlled breeding, there is possibility of inbreeding. The inbreeding rate (ΔF) was estimated using Wright's equation (Falconer and Mackay 1996). It was calculated as:

$$\Delta F = \frac{1}{(2N_e)} \quad (2)$$

where N_e is the effective population size per breeding population. N_e was computed as:

$$N_e = \frac{4N_m N_f}{N_m + N_f} \quad (3)$$

where N_m and N_f are the numbers of breeding cocks and hens scavenging together, respectively. The productive and reproductive performances were estimated in terms of the number of eggs per hen per clutch, number of clutches per hen per year, number of eggs hatched and chicks' weaned per hen per clutch.

Results

Farmers' and farms' characteristics

Table 1 presents the characteristics of the IC farmers and farms. The households were mainly headed by men (81.1%) within the age bracket of 15–87 years, with mean age of 42 years. Majority of the household heads (83.7%) had received formal education. The average age and level of education of the household heads, however, differed significantly between the counties ($P<0.05$). The mean household size was 7 dependents and the main source of livelihood was farming (51.3%) in medium- to high-potential agricultural areas and livestock production (15.7%) in ASALs. Households that depended on formal and informal employment and off-farm business constituted 13.7%, 12.7% and 6.6%, respectively (Table 1).

Land was privately owned with mean holding of 6.98 acres per household, but the size differed significantly between the counties ($P<0.05$, Table 1). Land allocation to different farm enterprises was consistent with the major occupation of the households. For example, in medium to high agricultural counties, food crop production was given priority, whilst in ASALs livestock were allocated the largest portion. The main livestock species kept in all the counties included cattle, goats and IC, but the numbers varied between counties ($P<0.05$, Table 1).

Table 2 shows the ranking of different livestock species as a source of income in the households, objectives for

Table 1 Characteristics of indigenous chicken farmers and farms

Variables	Counties						Overall mean	Range
	Siaya (n=98)	Kakamega (n=122)	Bomet (n=99)	Narok (n=96)	West Pokot (n=87)	Turkana (n=92)		
Farmers' characteristics								
Household head (%)								
Male	65.3	80.4	91.9	81.3	89.5	79.3	81.1	
Female	34.7	19.6	8.1	18.8	10.5	20.7	18.9	
Education level (%)								
Illiterate	6.1	7.2	7.4	22.0	24.1	39.3	16.3	
Primary	49.5	51.5	48.9	38.5	41.0	28.6	44.1	
Secondary	25.3	30.3	27.7	27.5	27.7	20.2	26.6	
Post-secondary	19.2	11.3	16.0	12.1	7.2	11.9	13.0	
Main occupation (%)								
Farming	64.2	65.5	62.0	61.7	33.3	15.2	51.3	
Livestock production	9.5	2.7	20.2	6.4	46.4	31.5	15.7	
Off-farm business	11.6	5.5	1.0	4.3	1.1	17.4	6.6	
Formal employment	8.4	11.8	13.0	14.9	12.0	21.7	13.7	
Informal employment	6.3	14.5	4.0	12.8	7.1	14.1	12.7	
Age (years)	46.54±0.6ac	48.43±0.4c	42.51±0.4ab	37.59±0.5b	40.39±0.4ab	38.60±0.6b	42.92±0.6	15–87
Household size	6.99±0.3a	7.63±0.1ac	6.3±0.4ab	4.94±0.3b	7.57±0.2ac	8.52±0.3c	7.11±0.3	1–18
Farms' characteristics								
Land size (acres)	6.68±0.1a	2.75±0.3ac	6.19±0.1a	14.57±0.3b	7.35±0.2ad	4.11±0.3a	6.98±0.3	0.2–69.25
Livestock	1.77±0.1	0.5±0.2	1.16±0.1	3.41±0.2	5.25±0.63	3.00±0.1	2.52±0.2	
Food crops	3.53±0.3	1.55±0.2	3.35±0.2	3.82±0.2	2.10±0.1	1.11±0.2	2.60±0.3	
Cash crops	1.38±0.1	0.7±0.3	1.68±0.2	7.34±0.2	0	0	1.85±0.2	
Livestock flock size								
Cattle	6.34±0.6	3.79±0.3	6.29±0.5	20.87±3.5a	6.81±0.6	21.32±4.2a	8.77±0.8	1–200
Goats	6.08±0.5a	3.18±0.3a	4.30±0.4a	30.41±4.7b	24.30±2.5b	29.85±6.6b	15.41±1.9	1–400
Camel	–	–	–	–	4.33±1.2a	11.30±4.5b	2.69±3.6	1–50
Donkey	2.20±0.3	–	1.20±0.08	2.59±0.3	–	3.83±0.8a	1.98±0.2	1–10
Indigenous chicken	23.93±1.7a	23.93±1.4a	23.59±1.2a	25.27±1.9b	20.60±1.5c	20.19±1.5c	22.40±0.8	1–81

Means followed by different letters in the same row are statistically different ($P<0.05$)

Table 2 Mean ranks of livestock species as source of household income, objectives of raising indigenous chicken and constraints faced by indigenous chicken farmers (1=most important and 7 least important)

Variables	Counties						Mean	Sig
	Siaya	Kakamega	Bomet	Narok	West Pokot	Turkana		
Livestock species as sources of household income								
Cattle	2.13±0.3	2.1±0.1	1.84±0.3	1.49±0.6	2.23±0.4	2.54±0.3	2.00±0.3	–[a]
Goats	2.38±0.6	2.63±0.2	2.67±0.4	1.92±0.3	1.62±0.4	1.42±0.1	2.10±0.2	–[a]
Camel	–	–	–	–	3.50±0.0	3.42±0.7	3.44±0.5	
Donkey	3.0±0.1	6.0±0.7	4.02±0.2	3.59±0.4	4.00±0.1	3.83±0.3	3.82±0.4	–[a]
IC	1.3±0.3	1.36±0.1	1.65±0.3	1.97±0.1	1.84±0.1	1.78±0.5	1.60±0.2	–[a]
Reasons for raising IC								
Consumption	1.57±0.8	1.75±1.0	2.02±0.7	1.46±0.7	1.50±0.7	1.38±0.8	1.62±0.8	–[a]
Cash income	2.11±1.0	2.28±1.0	1.32±0.7	1.89±1.0	2.07±0.8	1.98±0.9	1.93±1.0	–[a]
Asset building	3.02±1.3	3.38±1.5	3.39±0.9	3.58±0.9	3.53±0.9	3.20±1.3	3.35±1.2	–[a]
Emergency	2.64±1.0	2.35±1.2	2.95±0.8	2.90±1.1	2.76±1.0	2.98±1.0	2.72±1.0	
Manure	4.12±0.9	4.35±1.6	3.41±0.9	3.63±1.0	4.41±1.1	3.43±1.8	3.90±1.2	–[a]
Ceremonial	3.92±1.3	3.26±1.3	3.00±0.5	3.79±1.4	4.55±1.1	3.06±1.2	3.64±1.3	–[a]
Cock fighting	4.09±1.8	5.58±1.4	5.67±1.5	4.38±1.5	6.83±0.4	7.00±0.0	4.90±1.8	–[a]
Constraints to IC production								
Marketing	3.85±1.9	3.53±1.6	3.25±1.2	3.61±1.8	3.45±2.1	3.27±1.8	3.49±1.8	
Diseases	1.89±1.5	1.53±1.1	1.77±0.9	1.89±1.3	2.06±1.4	1.87±1.3	1.82±1.3	
Feeding	3.40±1.6	3.59±1.3	2.85±1.4	2.69±1.6	3.78±1.4	3.49±1.8	3.34±1.6	–[a]
Housing	3.94±1.4	4.08±1.5	3.38±1.4	3.38±1.6	3.99±1.6	4.70±1.8	3.95±1.6	–[a]
Capital	3.73±1.6	3.41±1.8	3.00±1.5	4.29±1.8	3.96±1.8	4.48±1.4	3.79±1.7	–[a]
Extension	3.72±1.8	3.77±1.7	4.02±1.5	4.13±1.8	5.11±1.8	3.60±1.5	4.12±1.8	–[a]
Predators	2.72±1.6	3.03±1.9	2.25±2.1	3.12±2.0	3.24±2.2	2.66±1.8	2.76±2.0	

[a] Mean ranks from different counties are significantly different ($P<0.05$)

raising IC and constraints faced by farmers. Generally, IC was ranked high in households with few numbers of cattle and goats as the main source of livestock income. The main reasons for raising IC were source of food, cash income and emergency for small cash income (Table 2). Other uses such as asset building, manure, ceremonial functions and entertainment (cock fighting) were ranked lower. Outbreak of diseases and parasites, predation, unavailability of quality feeds and poor marketing channels were the major challenges in IC production. Others like housing, lack of capital and extension services were also mentioned, but ranked low (Table 2).

The proportion of households practising different IC management practices in the six counties are presented in Table 3. Free range was the dominant production system practised by farmers (78%), followed by semi-intensive (12.7%); the intensive system was the least practised (9.3%) (Table 3). Chicken were mainly housed at night in the famers' main house (59%) and traditional houses (22.1%). Deep litter and deep litter-slatted floor housing were not popular with the farmers across the counties. Feed supplementation and watering of the birds were practised by 90.5% and 95.8% of the farmers, respectively (Table 3). Supplementation was, however, dependent on the availability of grains, e.g. chicken received more grains during harvesting seasons, but received little or no supplements during scarcity.

The IC healthcare was poorly undertaken across the counties, and majority of farmers (74.7%) did not have access to extension services. A few farmers got extension services from government officers, but they were not frequently available and did not offer extension services targeting IC production. Only 36% of farmers practised healthcare in their flocks, and most of them (52.2%) used ethno-veterinary medicine. Disease and parasite outbreaks were noted to be common during the wet and dry seasons, respectively. Newcastle disease and fowl typhoid diseases were ranked as the major causes of chicken deaths, whilst fleas, lice, mites and internal parasites (worms) were the most common parasites. Although egg selection for incubation was practised by most farmers, artificial egg incubation and chick brooding were only practised by 11.7% and 10.2% of the households, respectively (Table 3).

Table 3 Frequencies (%) of households practising different indigenous chicken flock management practices in the six counties

Variables	Counties						Mean (%)
	Siaya (n=98)	Kakamega (n=122)	Bomet (n=99)	Narok (n=96)	West Pokot (n=87)	Turkana (n=92)	
Production systems							
Free range	84.2	71.7	92.2	60.8	93.0	67.7	78.0
Semi-confined	9.9	15.0	3.9	34.0	1.2	10.8	12.7
Confined	5.9	13.3	3.9	5.2	5.8	21.5	9.3
Housing							
Main house	78.2	65.5	32.4	35.1	48.8	66.1	59.0
Traditional houses	10.9	20.4	37.3	24.7	37.2	30.7	22.1
Deep litter	7.9	8.8	13.7	17.5	1.2	1.1	8.6
Deep litter-slatted floor	3.0	5.3	16.7	22.7	12.8	2.2	10.3
Feed supplementation	93.5	92.9	92.0	94.4	90.7	90.4	90.5
Watering	98.1	95.0	94.1	97.8	97.6	93.9	95.8
Health management	33.0	36.9	33.6	34.4	33.4	25.3	36.0
Eggs selection	100	99.2	99.6	100	99.8	98.9	99.7
Artificial brooding	8.1	11.5	12.1	15.6	17.1	6.6	11.7
Artificial chick rearing	3.0	11.5	11.1	6.2	15.9	14.3	10.2

Indigenous chicken flock characteristics

The IC flock size, structure, dynamics, performance and inbreeding rates in the six counties are presented in Table 4. Generally, the trend on the flock composition, dynamics and management practices followed the same pattern in all the counties. The mean flock size was 22.40 chickens per household, but was significantly different between counties (P<0.05). The flock structure was mainly dominated by chicks (35.6%), growers (28.4%) and hens (27%), whilst cocks were the least (9%) (Table 4). The average cock-to-hen ratio was 1:3 per household, but only 46% of the households kept breeding cocks whilst the rest depended on neighbours' cocks. The breeding stock especially the cocks were retained in the breeding population for at least 3 years and were culled only due to age. On-farm hatching using broody hens was the main source of replacement stock (84.5%), whilst losses due to mortality and predation constituted 44% and 8% of exits from the farms, respectively. Culling of chicken for home consumption, sales, donations and exchange with other farmers contributed 21.5%, 17.0%, 5.5% and 4.0% of the chicken exits, respectively (Table 4).

The rate of inbreeding was calculated based on the number of breeding cocks and hens that were scavenging together. Chicken from five households were observed to scavenge together and mate freely. The average number of breeding cocks and hens scavenging together was estimated at 4.62 and 30.15, respectively, with a mean effective population size of 16.02 (Table 4). The estimated inbreeding rate per generation ranged from 2.98% to 3.28%, with a mean of 3.21%. The average egg production per hen per clutch and the number of clutches per hen per year were 15.37 eggs and 3 clutches, respectively. Most of the eggs laid (86.7%) were incubated with a mean hatchability of 83.6%, and chick survival are of 56.3% to weaning. Growers attained maturity at an average age of 6.43 and 6.06 months with corresponding average weights of 1.58 and 2.22 kg (Table 4).

Discussion

Farmers' and farms' characteristics

Understanding of the production systems, management and breeding practices, benefits derived from IC and the constraints faced by farmers are essential in the development of a holistic breeding improvement programme. The dependency of rural households on agriculture (livestock and crop production) (Table 1) for livelihood reported in this study concur with findings reported elsewhere in developing countries (Moges et al. 2010; Yakubu 2010; Osei-Amponsah et al. 2011). This dependency is of great importance in the utilization and conservation of animal genetic resources (Tixier-Boichard et al. 2009; Prentice and Anzar 2011). The high dependency on crop production compared to livestock in medium- to high-potential areas (Table 1) could be due to small land holdings, long time taken by livestock to attain market value and poor marketing channels for livestock and livestock products. The availability of large parcels of land in ASALs is,

Table 4 Indigenous chicken flock structure, dynamics, performance and levels of inbreeding in six counties

Variables	Counties						Percentage	Mean	Range
	Siaya	Kakamega	Bomet	Narok	West Pokot	Turkana			
Flock structure									
Cocks	2.14±0.4	1.99±0.1	2.06±0.4	2.03±0.3	2.10±0.2	1.92±0.4	9.0	2.01±0.1	0–16
Hens	5.66±0.5	5.67±0.4	7.02±0.6	7.50±0.7	4.90±0.4	5.50±0.4	27.0	6.03±0.1	1–49
Pullets	5.00±0.6	4.80±0.5	4.35±0.6	4.40±0.6	3.10±0.6	3.27±0.3	18.0	4.01±0.3	1–40
Cockerels	2.11±0.4	2.37±0.3	2.12±0.5	2.34±0.3	2.70±0.3	2.30±0.2	10.4	2.32±0.2	1–21
Chicks	9.04±0.9	9.10±0.9	8.04±0.7	9.00±1.2	7.80±0.9	7.20±0.8	35.6	8.02±0.1	1–50
Mean	23.93±1.7a	23.93±1.4a	23.59±1.2a	25.27±1.9b	20.60±1.5c	20.19±1.5c		22.40±0.8	
Flock dynamics									
Hatching	37.92±2.6	33.32±2.7	18.39±1.5	30.90±0.3	27.62±3.2	28.27±2.6	84.5	30.5±2.7	1–81
Purchases	4.32±1.0	4.72±1.2	5.16±0.7	3.58±0.92	4.81±1.0	10.30±2.1	15.5	5.6±0.9	1–55
Sales	9.64±1.0	6.64±0.8	4.15±0.5	7.43±1.0	5.47±0.7	7.19±1.0	17.0	9.3±3.3	1–48
Consumption	9.67±1.3	9.26±1.2	6.34±0.6	7.49±1.5	9.25±1.2	8.47±1.0	21.5	11.4±0.7	1–58
Diseases and parasites	17.07±1.7	19.68±2.3	11.85±2.0	14.21±2.1	13.88±1.3	13.20±1.7	44.0	24.0±3.2	1–80
Predators and stolen	12.18±1.8	4.15±1.3	3.75±1.3	8.41±2.7	5.45±1.8	9.40±2.5	8.0	4.3±0.8	1–43
Donations	6.23±1.0	5.79±1.5	2.71±0.4	3.15±0.4	3.08±0.6	6.03±1.0	5.5	3.0±0.4	1–37
Exchange	5.71±1.0	5.00±1.0	2.90±0.7	3.08±0.6	3.13±0.9	4.60±1.1	4.0	2.4±0.5	1–25
Performance of chickens									
Egg yield/hen/clutch	16.52±0.5	16.95±0.4	16.29±0.5	18.38±0.8a	15.97±0.6	14.76±0.8		15.37±0.6	7–18
Clutches/hen/year	3.14±0.6	3.06±0.6	3.28±0.6	3.52±0.1a	3.27±0.8	3.09±0.1		3.1±0.7	2–4
Eggs Incubated	12.79±0.4	11.85±0.2a	12.43±0.3	12.51±0.4	12.98±0.6b	12.28±0.7		12.84±0.4	7–15
Chicks hatched	10.94±0.4	10.59±0.3	11.13±0.4	10.67±0.5	11.16±0.5	9.58±0.7a		10.73±1.8	5–15
Chicks weaned/hen/clutch	6.69±0.3	6.75±0.3	7.59±0.4a	7.00±0.8a	5.17±0.5	5.71±0.7		6.04±1.4	2–8
Age at first egg (Months)	5.94±0.2a	6.74±0.2	5.61±0.3a	6.98±0.2	6.14±0.3	6.80±0.3		6.43±0.3	5–11
Age at first crow (Months)	5.43±0.3a	6.22±0.2	5.48±0.2a	6.46±0.3	6.00±0.1	6.05±0.3		6.06±0.2	5–10
Body weight at maturity									
Cocks	2.09±0.3	2.11±0.1	2.58±0.2	2.21±0.3	1.98±0.4	1.97±0.3		2.22±0.1	6–11
Hens	1.54±0.2	1.59±0.4	2.00±0.3	1.64±0.1	1.47±0.1	1.46±0.4		1.58±0.6	5–10
N_e^1	6.21	5.89	6.37	6.39	5.88	5.69		6.03	
N_e^2	16.77	15.77	16.70	16.61	16.14	15.23		16.02	
F^1 (%)	8.05	8.50	7.85	7.82	8.50	8.78		8.25	
F^2 (%)	2.98	3.17	2.99	3.01	3.10	3.28		3.12	

Means followed by different letters in the same row are statistically different ($P<0.05$)

Ne^1, Ne^2 effective population size at household and village levels, respectively; F^1, F^2 inbreeding rate per generation at household and village level, respectively

however, an opportunity for utilization of livestock as observed in this study.

Flock characteristics and attributes

The dominance of IC in medium to high agricultural areas could be due to their requirement for small space and availability of grains. Large proportions of land in these areas are dedicated to crop production, and therefore there is less or no space left for large livestock species. The harsh environmental conditions (high temperatures and scarcity of grains) in ASALs could also explain the low productivity, small flock size and therefore low ranking of IC as a source of livestock income (Table 4). Small flock sizes, low productive and reproductive performances, and high mortalities of IC have been reported in marginal agro-ecological zones in the tropics (Mtileni et al. 2009; Moges et al. 2010; Yakubu 2010).

The high ranking of IC as a source of food security and cash income observed in this study (Table 2) agrees with those reported in other developing countries in Africa and Asia (Sekeroglu and Aksimsek 2009; Dana et al. 2010). The fact that chicken are easy to slaughter, can be consumed as a single meal and therefore do not require

storage facilities, and their products have no cultural, gender and religious taboos (Meseret et al. 2011) compared to large animals could explain their popularity as a major source of animal protein. The readily available markets and the ever-increasing demand for IC products especially live chicken both in the rural and urban households (Bett et al. 2011; Meseret et al. 2011) explain their high ranking as a source of income.

Indigenous chicken management practices

The dominance of free-range production systems and feed supplementations observed in this study concurs with those reported in the literature (Dana et al. 2010; Hailemariam et al. 2010; Moges et al. 2010). The housing of chicken in the farmers' houses was a way of reducing the input costs. Although scavenging chickens have been reported to be able to meet their nutritional requirements (Kingori et al. 2010), the increasing human population accompanied by land division in the agricultural regions and climatic change could pose a challenge to scavenging chickens in the future. There is therefore a need to look for alternative feed resources for chicken to reduce competition with humans for grains. Research should be done on drought-tolerant cereal crops to provide constant supply of grains. Studies on nutritional values and conventional strategies of harnessing termites to feed chicken are also necessary. Feeding termites to chicken provides a mechanism for converting unusable cellulose into food for human consumption with benefits to the ecosystem. Termites thrive well in dry conditions and mostly feed on dead plant materials such as wood, leaf litter and animal dung. Their recycling of wood and other plant matter is of considerable ecological importance. This may help increase the flock size and performances of the chicken, especially in the ASALs.

Health management has been reported as the major challenge faced by farmers in developing countries (Mwale and Masika 2009; Kaingu et al. 2010). The seasonal outbreak of diseases, especially Newcastle disease and fowl typhoid observed in this study, has also been reported to cause high mortalities elsewhere (Dana et al. 2010; Moreki 2010; Yakubu 2010). Notification of the season of outbreaks in this study could be used to schedule vaccination programmes against these diseases, i.e. chickens can be vaccinated during dry seasons so that they develop immunity before the outbreaks in the wet seasons. Before such vaccination programmes are put in place, farmers may continue using ethno-veterinary medicine such *Aloe secundiflora* and *Aloe ferox* (Mwale and Masika 2009; Kaingu et al. 2010) to treat and control diseases. Dependency on herbs, however, may be short-lived because of climate change and loss of local indigenous knowledge through generations. This calls for the inclusion of disease resistance in the breeding objective of IC as it is permanent and can be passed on to future generations.

Household flock structure, mating practices and performances

The mean chicken flock size per household and flock structure obtained in this study (Table 4) is in agreement with studies in other developing countries where a mean flock size between 12 and 24 per household, with chicks constituting the largest proportion, has been reported (Mtileni et al. 2009; Yakubu 2010). The mean mating ratio found in this study was comparable to those reported in Ethiopia, Nigeria and South Africa (Mtileni et al. 2009; Dana et al. 2010; Yakubu 2010). The high rate of inbreeding (3.12%) observed in this study (Table 4) could be explained by the low effective population size, dominance of some few cocks due to cock fighting during scavenging, retention of cocks in the breeding flock for a long time and dependency on neighbours' cocks by most households. Although the inbreeding rate obtained in this study was lower than 12.36%, 5.52% and 3.85% reported in Ethiopia, Jordan and Malawi, respectively (Abdelqader et al. 2007; Gondwe and Wollny 2007; Dana et al. 2010), it was higher than the acceptable level of 1–2% per generation (Henson 1992). Farmers should therefore be encouraged to exchange breeding cocks which already have mature offspring within the flock with other farmers located farther than the scavenging distance to reduce inbreeding.

The productive and reproductive performances of the IC in the current study compared well with those reported in the literature (Moges et al. 2010; Yakubu 2010; Ochieng et al. 2011). The high performances for IC in medium- to high-potential agricultural zones than those in the ASALs could be due to better management in terms of feeding and housing which allows chickens to express their genetic potentials. This concurs with previous studies which have reported an improved performance of IC in semi-intensive and intensive production systems (Magothe et al. 2010; Ochieng et al. 2011). This implies that the performance of IC can be improved by good management. However, a holistic approach should be considered because the performances are influenced by both managerial and genetic factors.

In conclusion, this study has demonstrated that IC forms an integral part of the rural households in terms of food and nutrition provision, cash income and emergency for small cash income. However, major constraints such as disease and parasite outbreaks, lack of quality feeds, poor marketing channels and small population size translating to high inbreeding rates need urgent mitigation measures. There is therefore a need to package the management intervention strategies to reduce losses associated with disease and parasites, and poor nutrition and develop marketing

channels. Sustainable genetic improvement programmes that account for farmers' multiple objectives, market requirements and the production circumstances should be designed in order to improve IC productivity.

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