

Full Length Research Paper

Ethiopian native chicken productivity, aims of production and breeding practices across agro-climatic zones

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This study was conducted to characterize flock size, composition, productivity, motivational drivers, and breed selection criteria in village chicken production systems of lowlands, midlands, and highlands of Ethiopia. Data were collected at 360 rural households of which 120 were from lowland, 160 midland, and 80 highlands. A standardized questionnaire was used to collect the data using person to person interview method. Data were analyzed using the various statistical procedures of statistical analysis system (SAS) version 9.2. Higher flock size and productivity of chicken were obtained for midlands than the other agro-ecologies. The average flock size per household was 16.6. The average age at sexual maturity of hens was 7 months. Average number of egg production was 43 eggs per hen per year. Average hatching rate was in the range of 76 to 82%. Mortality occurred in the range of 27 to 39%. Although, village chicken has diverse use in Ethiopian rural community, the main motivations to keep village chicken were egg production followed by income generation. Eggs were mainly used for hatching, home consumption, and to generate a daily disposable income. The three most important breed selection criteria were egg production, morphometric characteristics, and mothering ability. Findings from this study can support the design of agro-ecology based breeding strategies aiming to improve native chicken production, productivity, and enhance their economic contributions to the farmers.

Key words: Ethiopian native chicken, breed selection criteria, flock productivity, motivational drivers.

INTRODUCTION

Village chickens represent the majority of poultry production in developing countries, and are mainly kept under extensive production system which is characterized by high disease and parasite infestation, predation, harsh climatic conditions, unavailability and

less quality feeds, and uncontrolled breeding (Malatji et al., 2016; Jansen et al., 2009; Msoffe et al., 2009; Sekeroglu and Aksimsek, 2009; Kumaresan et al., 2008; Gondwe and Wollny, 2007).

Despite the low performances of village chickens, they

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possess several favourable characteristics which enable them to cope with the extensive form of management system. They are very well adapted to local conditions, resistant to disease, have brooding ability, and depend on scavenging for feed (Tarwireyi and Fanadzo, 2013; Harrison and Adlers, 2009; Msoffe et al., 2009; Mwale and Masika, 2009; Olwande et al., 2009; Gondwe and Wollny, 2007; Scanes, 2007; Kondombo, 2005).

Like in other African countries, the production and productivity of Ethiopian village chickens are generally low (Assefa et al., 2016; Salo et al., 2016; Getachew et al., 2015; Zewdu et al., 2013; Mekonnen et al., 2010; Aklilu et al., 2007; Halima et al., 2007a; Ashenafi et al., 2004; Tadelle, 2003; Tadelle and Ogle, 2001; Tadelle, 1996). Their average age at sexual maturity (weeks), number of eggs per hen per clutch, number of eggs per hen per year, egg weight (g) and hatching rate (%) are ranged from 26 to 28, 14 to 16, 46 to 91, 43 to 47, and 79 to 89%, respectively (Worku et al., 2012; Moges et al., 2010a; Moges et al., 2010b).

As village chickens are entirely depending on scavenging for their feed, their performances for various economically important traits could be considerably affected by agro-climatic factors. The effect of agro-climate on chicken production and productivity and farmers' management practices were previously studied in other African countries (Muchadeyi et al., 2009; Muchadeyi et al., 2007).

Although there have been few previously conducted agro-climate based chicken production system characterization studies in Ethiopia, there is still information gap in the area (Worku et al., 2012; Moges et al., 2010b). Those previously conducted studies only covered few districts in the country and few chicken production parameters.

Therefore, the objectives of this study were to characterize village chicken flock size, composition, productivity, aims of production, and breed selection criteria at national level and across major agro-climatic zones in the country. The study is expected to generate key information that can be used for developing agro-ecology based breeding strategies aiming to improve native chickens of the country.

MATERIALS AND METHODS

Study sites

In this study, nine districts were selected from four regions in Ethiopia (Oromia, Amhara, Southern Nations, Nationalities and People region (SNNP), Tigray) where village chicken production predominate, and have an easy access for transportation.

Among the nine districts, the Dodota, Haremaya and Ada districts were selected from Oromia region (3°N to 10.5°N latitude; 34°E to 43°E longitude), the Gonder Zuria and Basonaworna districts were selected from Amhara region (9° 21' to 14° 0' N latitude; 36° 20' to 40° 20' E longitude), the Arbaminch Zuria, Abeshge and Malga districts were selected from the SNNP (6°3'31.03" latitude; 36°43'38.28" longitude), and the North Mekele district was selected

from Tigray region (13° 14' 06" N latitude; 38° 58' 50" E longitude).

The selected districts were categorized into three groups as lowland, midland and highlands based on their traditional form of classification which depends on altitude, temperature and rainfall. Based on this classification, lowlands were represented by the Arbaminch Zuria, Abeshge, and Dodota districts. Midlands were represented by the Ada, Gonder Zuria, Haremaya and North Mekele districts, whereas, highlands were represented by the Basonaworna and Malga districts.

The lowland areas were characterized by an altitude in the range of 500 to 1,500 m.a.s.l with an annual rainfall of 200 to 800 mm, and a temperature of 20 to 27.5°C, whereas the midland areas represented an altitude in the range of 1,500 to 2,300 m.a.s.l with an annual rainfall of 800 to 1,200 mm and temperature of 17.5 to 20.0°C, which was mainly characterized by mixed crop-livestock farming.

On the other hand, highlands were featured by an altitude in the range of 2,300 to 3,200 m.a.s.l with an annual rainfall of 900 to 1,200 mm, and a temperature of 11.5 to 16.0°C. Highland districts were mainly characterized by crop production, but mixed crop-livestock farming system was also common in this area (Figure 1).

Sampling procedure

A multi-stage sampling procedure was employed to select sampling locations and target households. In each district, four villages were selected, and 10 households that had a minimum of five chickens were randomly selected in each village. In total, 360 households: 80 from highlands, 160 midlands, and 120 lowlands were considered. Person to person interview was made to collect qualitative and quantitative data on chicken flock size and composition, productivity, motivational drivers, breed selection criteria and farmers' socio-economic features using a standardized questionnaire. Data collection was supported by the technical staffs of the agricultural and rural development offices in Ethiopia. Agro-climatic data of the selected districts were obtained from the respective agricultural and developmental main offices in Ethiopia.

Statistical analyses

The data were coded and stored on a database. A generalized linear model procedure of statistical analysis system (SAS) version 9.2 (SAS Institute Inc., 1999) was used to study the effect of agro-climate on the studied parameters like chicken flock size, composition and productivity (Tables 1 and 2). The three agro-climatic zones: lowlands, midlands and highlands were considered as fixed effect in the model. Rank means were compared using a non-parametric Kruskal Wallis test (NPAR1WAY) procedure of SAS version 9.2 (SAS Institute Inc., 1999) for non-measurement variables like motivation to keep chicken and breed selection criteria (Tables 3 and 4). Alpha level of 0.05 was used to reject the null-hypothesis of no difference on the studied parameters across the three agro-climatic zones.

RESULTS AND DISCUSSION

Socio-economic features of chicken farmers

As previously reported by Goraga et al. (2016), 56.3% of the 360 respondents were males and 43.8% were females. The respondents had an average age of 38 years, and 84.9% were married. Regarding their religion, 45.9% of them were Orthodox, 22.5% were Muslim, and

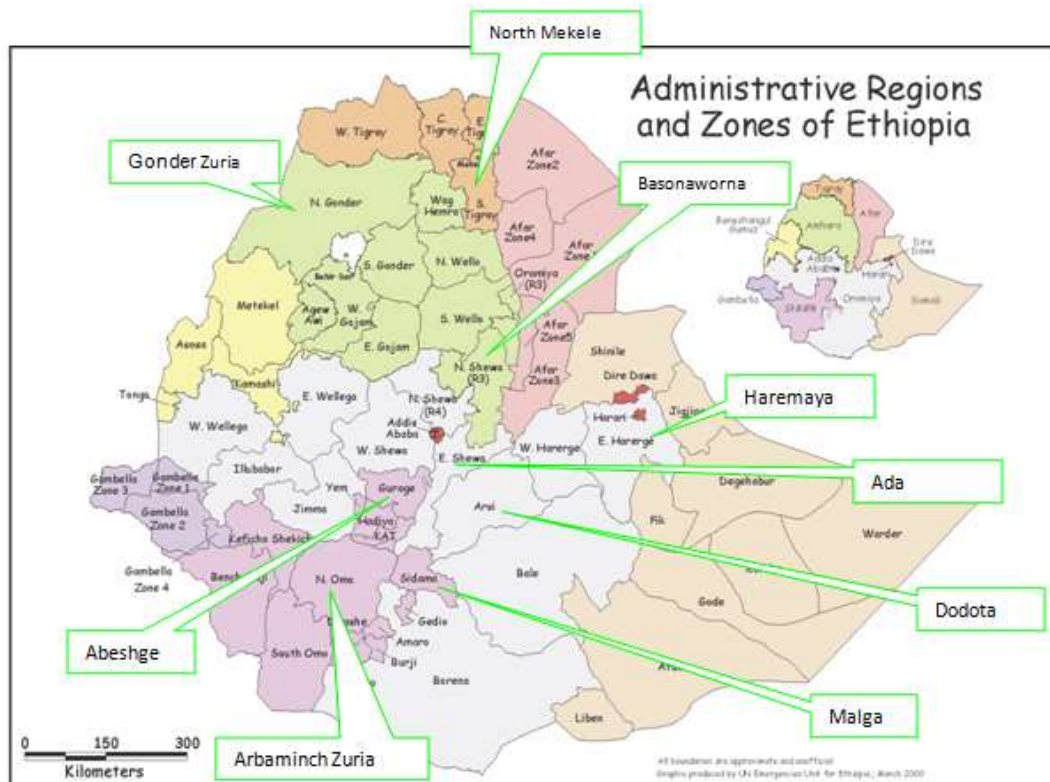


Figure 1. Sampling sites in Ethiopia. Administrative regions (small Map), zones (big Map), two city-states (red colour), and selected districts (green coloured boxes).

Table 1. LSmeans and standard errors of chicken flock size and composition by agro-climatic zone.

Parameter	Agro-climatic zones			Overall means
	Lowlands	Midlands	Highlands	
Number of households	120	160	80	-
Chicken flock size				
Chicks	5.3 (0.57) ^a	8.5 (0.56) ^b	4.9 (1.07) ^a	6.2
Pullets	2.8 (0.26) ^a	4.6 (0.23) ^b	2.3 (0.33) ^a	3.2
Cockerels	1.9 (0.21) ^a	3.1 (0.17) ^b	1.7 (0.25) ^a	2.2
Hens	3.0 (0.22) ^a	3.8 (0.20) ^b	3.0 (0.26) ^a	3.3
Cocks	1.7 (0.22) ^a	2.3 (0.16) ^b	1.2 (0.20) ^a	1.7
Total	14.7 (0.91) ^b	22.3 (0.79) ^c	13 (1.06) ^a	16.6

The same superscripts in rows are not significantly different ($P>0.05$). LSmeans refers to least square means.

17.6% were Protestant. 64.9% of the respondents were literate and 35.1% were illiterate. The average family size was composed of 6 members. The households had on average 1.7 ha of land. In lowlands, farmers had on average 0.46 and 0.20 ha more land than those living in midlands and highlands, respectively. 83.1% of the total households were engaged in farming activities. Only 16.9% were engaged in off-farming activities. Most of the households came from families who had farming

background.

Flock size and composition

The average flock size per household is 16.6. The flocks were composed of 37.3, 19.3, 13.3, 20 and 10.1% chicks, pullets, cockerels, hens, and cocks, respectively (Table 1). Flock size differed ($P<0.05$) by agro-climatic zone.

Table 2. LSmeans and standard errors of chicken production performance by agro-climatic zone

Parameter	Agro-climatic zones			Overall means
	Lowlands	Midlands	Highlands	
Number of households	120	160	80	-
Egg production traits				
AFE (in weeks)	31.7 (0.6) ^c	24.8 (0.56) ^a	27.8 (0.77) ^b	28.1
Clutch number	2.9 (0.08) ^b	2.4 (0.07) ^a	3.2 (0.09) ^c	2.83
Eggs per clutch	14.5 (0.44) ^a	16.2 (0.39) ^b	14.4 (0.52) ^a	15
Number of eggs per year	43 (1.84) ^a	42 (1.66) ^a	45 (2.14) ^a	43
Eggs in a set	10.9 (0.28) ^a	12.2 (0.24) ^b	12.1 (0.33) ^b	11.7
Hatchability (%)	76.4 (1.28) ^a	80.2 (1.14) ^b	81.9 (1.54) ^b	79.5
Mortality (%)	39.5 (2.90) ^b	27.9 (2.56) ^a	33.4 (3.40) ^{ab}	33.6

The same superscripts in rows are not significantly different ($P>0.05$). LSmeans refers to least square means.

Table 3. Rank means and standard deviations for motivations to keep chicken (1=most important up to 5=least important).

Parameter	Agro-climatic zones			Sig ^b
	Lowlands	Midlands	Highlands	
Number of households	120	160	80	-
Motivations				
Egg	2.0 (2.03)	3.6 (2.50)	2.4 (2.2)	***
Meat	4.5 (1.92)	5.8 (0.84)	5.8 (0.83)	***
Income	3.5 (2.18)	2.4 (1.98)	3.1 (2.2)	***
Manure	5.9 (0.18)	6.0 (0.00)	5.9 (0.62)	NS
Hobby	5.9 (0.45)	5.9 (0.31)	5.9 (0.49)	NS
Sig ^a	***	***	***	-

Sig^a refers to significance of rankmeans of motivational drivers within agro-climatic zone and Sig^b significance of rankmeans across agro-climatic zones. Significant at $P<0.05$ (*), $P<0.01$ (**), and $P<0.001$ (***). Rank means were compared using Kruskal Wallis test.

Table 4. Rankmeans and standard deviations attached to breed selection criteria (1=most important up to 5=least important).

Parameter	Agro-climatic zones			Sig ^b
	Lowlands	Midlands	Highlands	
Number of households	120	160	80	-
Breed selection criteria				
Egg	3.2 (1.78)	2.5 (1.87)	4.4 (1.36)	***
Growth	3.8 (1.83)	4.2 (1.61)	5.0 (0.00)	**
Mothering ability	4.4 (1.22)	4.6 (0.95)	3.5 (1.65)	***
Disease resistance	4.4 (1.14)	4.4 (1.21)	5.0 (0.00)	*
Morphometric characteristics	4.3 (1.21)	4.2 (1.54)	1.6 (1.49)	***
Sig ^a	*	***	***	-

Sig^a refers to significance of rankmeans of breed selection criteria within agro-climatic zone and Sig^b significance of rankmeans across agro-climatic zones. Significant at $P<0.05$ (*), $P<0.01$ (**), and $P<0.001$ (***). Rank means were compared using Kruskal Wallis test.

Chicken farms in midlands had higher flock size than those in lowlands and highlands. The average number of chicks, pullets, cockerels, hens, and cocks per household is not different between lowlands and highlands.

Average flock size of 12.1, 12.9 and 14.4 was previously reported in Ethiopia (Mekonnen et al., 2010), Malawi (Gondwe and Wollny, 2007), and Mozambique (Harrison and Adlers, 2009), respectively. These flock sizes were lower than the flock size of 16.6 which was obtained in the present study. However, higher flock sizes 19 and 33.5 were reported in Kenya and Burkina Faso, respectively (Olwande et al., 2009; Kondombo et al., 2003).

The flocks in the present study mainly composed of chicks and pullets in midlands and chicks in lowlands and highlands. Overall flock composition was dominated by chicks. The higher flock size obtained in midlands than the other two zones might be associated with better management and environmental conditions. Flock size and composition was different in the three agro-climatic zones.

This is in agreement with previous findings in Zimbabwe (Muchadeyi et al., 2007). The average flock size generally at African rural households is small. Lower flock size especially for hens can attribute to lower egg production at farm level.

Flock productivity

Hens reached sexual maturity on average at 7 months. They had on average 2.8 clutches per year, and laid 15 eggs per clutch. Average number of egg production was 43 eggs per hen per year (2.83 clutch number \times 15 eggs per clutch). The hatchability and mortality rate are 79.5 and 33.6%, respectively. Production performance and mortality rate of rural chicken differed ($P < 0.05$) in the three agro-climatic zones (Table 2).

In midlands, hens reached sexual maturity 3 and 6.9 weeks earlier than hens in highlands and lowlands, respectively. Hens in highlands had the highest clutch numbers. Hens in midlands laid on average 1.7 and 1.8 more eggs per clutch than hens in lowlands and highlands, respectively. Low hatchability (76.4%) was obtained in lowlands. Similar hatchability rates were obtained in midlands (80.2%) and highlands (81.9%). Mortality rate is the highest in lowlands (39.5%).

All egg parameters except number of eggs laid per hen per year (clutch number \times eggs per clutch) differed ($P < 0.05$) by agro-climatic zone. Average hens' sexual maturity obtained in the present study is 28 weeks which is in agreement with values (28 to 38 weeks) reported by Halima et al. (2007b). Hens in lowlands reached sexual maturity 6.9 and 3.9 weeks later than those in midlands and highlands, respectively.

Higher number of eggs per clutch and eggs in a set were obtained in midlands. In highlands, higher clutch

number and hatchability were obtained. Hens in lowlands were characterized by late age at sexual maturity, lowest number of eggs in a set, lowest hatchability, and highest mortality.

Most of the present findings on egg parameters such as age at sexual maturity, clutch number, number of eggs per clutch, total egg production per year, hatchability, and mortality were in the range between values reported previously in Ethiopia (Halima et al., 2007a; Tadelle and Ogle, 2001). The numbers of eggs per clutch and percent hatchability obtained in this study were higher than the values reported in Burkina Faso (Kondombo et al., 2003).

Generally, the low performances of hens of rural chicken for egg production traits could be partly explained by the late age at sexual maturity and long times spent for incubating eggs and taking care of their chicks (Olwande et al., 2009). The observed differences in hens laying performance across the three agro-climatic zones might be due to the variations in resource availability, management practices, disease infestation, and climatic factors among the different zones.

Motivation to keep rural chicken

Farmers ranked the motivations to keep chicken from most important (1) to least important (6). In lowlands, the motivations to keep chicken are mainly attached to egg production (2.0 ± 2.03) and income generation (3.5 ± 2.18).

In midlands, farmers keep chicken mainly for income generation (2.4 ± 1.98) and egg production (3.6 ± 2.50). The motivations to keep chicken in highlands were similar to the motivations in lowlands. Generally, rural farmers in Ethiopia keep chicken mainly for egg production (2.7 ± 2.2). The eggs are used for hatching, home consumption, and generation of a daily disposable income. The observed motivational drivers in village chicken production are different both within and between agro-climatic zones (Table 3).

The aims of production at rural chicken farms might differ among countries and across agro-ecological zones within a country (Jansen et al., 2009; Muchadeyi et al., 2007; Henning et al., 2006). In the present study, similar situation was observed, that is, the motivations to keep chicken differed among the three agro-climatic zones. In lowlands, the motivations to keep chicken were mainly attached to egg production (1st) and income generation (2nd). In midlands, farmers keep chicken mainly for income generation (1st) and egg production (2nd). The motivations to keep chicken in highlands are similar to the motivations in lowlands.

Data analysis using the whole data set (360 households) revealed that Ethiopian rural farmers keep chicken primarily for egg production which is the basis for hatching, home consumption, and generating a small daily disposable income. About 23% of eggs produced at rural household go to the market (Tadelle and Ogle,

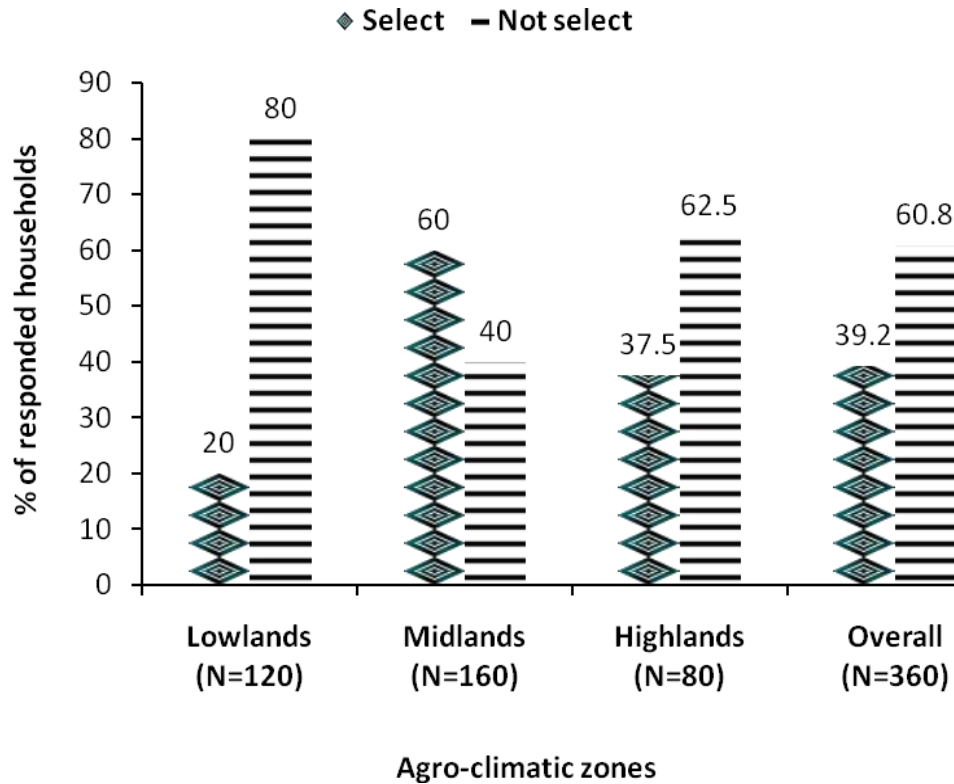


Figure 2. Percentage of village chicken producing households selecting or not selecting parents and/ or breeds for breeding purpose.

2001). Unlike in Ethiopia, meat production was reported as the chief role of chicken to the households in South Africa (Mwale and Masika, 2009).

Breed selection criteria

Breed selection criteria are egg production, growth performance, mothering ability, disease resistance and morphometric characteristics. About 60.2% of the 360 households did not select chicken for breeding purpose (Figure 2). Only 39.8% of the households selected chicken for breeding based on one or more specific criteria.

The farmers ranked the aforementioned five breed selection criteria from most important (1) to least important (5). The criteria of breed selection are different in the three agro-climatic zones. Egg production (number and weight of eggs) as breed selection criteria is the most important in midlands (2.5±1.87) and lowlands (3.2±1.78). Mothering ability and morphometric characteristics are the most important in highlands. Breed selection criteria differed (P<0.05) also within agro-climatic zone.

For instance, in lowlands, egg productions followed by growth are the most important breed selection criteria. In midlands, selection is mainly depended on egg production

(2.5±1.87). Morphometric characteristics (e.g. plumage colour) followed by mothering ability (e.g. aggressiveness to predator, ability to hatch more eggs) are the most important breed selection criteria in highlands (Table 4).

This study shows that not many of the Ethiopian rural households do practice breed selection and this is in agreement with previous findings in other African countries (Olwande et al., 2009; Kondombo, 2005). Only 39.8% of all households select parents for breeding based on laying performance, morphometric characteristics (for example, plumage colour) and mothering ability (for example, aggressiveness against predators, ability for hatching). Differences in criteria of breed selection were observed both within and among agro-climatic zones, which is in agreement with the findings of Muchadeyi et al. (2009). Laying performance as the most important selection criteria agrees with the aim of production at farm level. Traits such as productivity, size of the eggs, broodiness, and alertness were previously mentioned as selection criteria (Tadelle, 2003).

Farmers in Zimbabwe choose breeding animals primarily based on body size followed by mothering ability, fertility, and morphological traits (Muchadeyi et al., 2009). Even if some farmers keep parents as a breeding stock, mating is uncontrolled as rural chicken spent their days in the field together with other flocks coming from



Figure 3. A typical free range layers production system practiced in Brazil. The chicken presented in this picture represent tropically adapted breed called Embrapa 051.

the nearby households. None of the households participated in this study practiced record keeping, which is in agreement with previous findings in other African countries (Muchadeyi et al., 2009).

Therefore, farmers select the best breeding stocks simply based on daily observation of the hens' performance. The disadvantage of this practice is that one cannot easily follow the pedigree information as there is no record keeping. In addition, it is difficult to remember the long term production performance of hens.

Conclusions

Like in other African countries, the Ethiopian village chicken production systems are characterized by small flock size and diverse flock composition where chicks account for the highest percentage of the flock size per farm. This study reveals that the production performances of Ethiopian village chicken are low. However, in most cases, the performances are comparable to the performances of native chicken kept in other African countries.

Agro-climate did affect many of the studied economically important traits such as age at sexual maturity, number of clutches per hen per year, number of eggs per clutch per hen, and hatching and mortality rates. Thus, it is very important to consider agro-ecological variations in any research interventions aiming to improve or evaluate the native chicken breeds kept in an extensive production system.

This study further reveals that egg production and income generation are the most important motivational drivers for keeping native chicken at Ethiopian smallholder

farmers' level. For this reason, the majority of the interviewed farmers did select their parental stocks mainly based on egg production performance followed by mothering ability and morphometric characteristics.

Despite the low performance of Ethiopian village chicken, their adaptability to low input and harsh environment conditions in an extensive chicken production systems need to be appreciated, and mechanisms need to be designed to improve the existing village chicken production systems both in terms of size of production and flocks' productivity. Alternatively, various model poultry production systems can be adopted from foreign countries to improve Ethiopian chicken production systems. A typical example can be introducing "a free range layers production system of Brazil (Figure 3)" where smallholder farmers can keep thousands of layers per small pieces of land and can collect several hundreds to thousands of eggs per day.

A free range layers production system can quickly ensure food security, generate huge daily income and improve livelihoods. Furthermore, the system can help to quickly satisfy the country's egg demand. In this system, farmers are expected to practice "all-in and all-out system" and start the production with three months old pullets and keep the flocks until culling age which is usually after two years of egg production. Implementation of improved free range layers production system requires a package composed of tropically adapted chicken breed (for example, Embrapa 051 or Bovan Brown), 600 to 800 m² of land, commercial feed, simple house which can be constructed with local materials, and fence for covering the scavenging field.

Therefore, model free range chicken production systems with tropically adapted and high egg yielding or dual

purpose chicken breeds need to be promoted in order to transform the existing small flock sizes and low performances in Ethiopia.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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