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Characterisation of the phenotypes associated with body growth and egg production in local chickens from three agro-climatic zones of Kenya

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Abstract

We aimed to characterize body growth and egg production phenotypes associated with local chickens in Kenya from different ecological zones. Data was collected from a total of 296 chickens spread across three agro-climatic zones: Lamu Archipelago (semi-arid coastal), Mt. Elgon catchment (humid highlands) and Lake Turkana basin (arid pastoral). The analysis of variance showed significant interactions between shank length, body length and live weight for meat production and the number of yolks per egg with a strong significance of 4.34e-13, 2e-16, <2e-16, and 0.01 respectively. However, we did not find any significant relationship between the numbers of eggs laid per hen per clutch, the number of eggs seated on per hen per clutch and the number of eggs hatched per hen per clutch, in the various agro-climatic zones.

Despite being the lightest and small bodied, chickens from Lake Turkana which had an average mean body weight (g) of 1190.96 ± 358.16 produced more eggs (9.42eggs ± 6.87eggs) than the heaviest and big bodied (Lamu Archipelago) which had an average body weight (g) of 2198.74 ± 656.32 and produced an average of 8.29 eggs ± 5.95 eggs per clutch. Mount Elgon catchment chickens had an average weight (g) of 1974.75 ± 572.92 and produced an average of 8.75 ± 7.77 eggs per hen. Lamu Archipelago had eggs with the highest number of double-yolked eggs with a frequency of 89%.

Generally, we revealed relevant production traits for meat and egg production among indigenous chickens from different ecotypes in different regions that historically were migration points of entry for humans and livestock into Kenya. We propose further genetic studies on the Lamu and Turkana Chicken ecotypes since these two are from regions in Kenya that have previously been understudied.

Key words: *chicken ecotypes, food security, meat, poultry, production systems*

Introduction

Chickens were domesticated in Asia over 8000 years ago and have spread worldwide to adapt in several agro-ecological zones. Chickens are especially important in developing countries since they provide a large proportion of protein in human diet in terms of meat and eggs. They have also been used for ornamental purposes for instance the silkie or bantams in China and also during entertainment for example game cocks used for cock fighting Magothe et al (2012). Kenya has about 32 million domesticated poultry and out of these, almost 70% are indigenous. These have not undergone any genetic improvement to form breeds and are distributed in several ecological zones i.e. local chicken ecotypes. On the other hand, the commercial and hybrid chickens constitute about 20% Kenya Bureau of Statistics (2009) and the remaining 10% comprises the other poultry such as turkeys, ducks, geese, quails, ostrich, pigeons and guinea fowls FAO (2007). Most of the local chicken ecotypes are kept by the majority rural poor to fulfill multiple functions among them supply of affordable protein in their nutrition and source of income FAO (2007). Local chicken ecotypes are reared under the free range system Okeno et al (2012) where they are left to scavenge for food, without any feed supplementation or veterinary inputs (Kingori et al 2010). Characterization of phenotypes is necessary for important production and adaptation traits. A study by Moraa et al (2015) was able reveal tolerance to heat stress as an important adaptation trait.

Different studies in Africa have revealed the existence of considerable variations in production traits (Shank length, Body Length, Live weight, No of eggs laid, number of eggs seated, and number of eggs hatched, Sitting times/year, number of yolks /egg among others) within and among local chicken populations FAO (2012, Adeleke et al (2011). Halima (2007) reported the existence of variations between genetic groups of local chicken in Ethiopia as indicated by high heterozygosity values. On the other hand, Ajayi (2010) reported the heritability estimates for body weight in the Nigerian local chicken populations that indicated the dual potential for development into a meat or egg strains.

The Results from these studies showed existence of many genotypes, phenotypes and varied productivity potential within local chicken populations hence indicating the possibility of improving genetic potential through selective breeding within and between local chicken populations. (Msoffe et al 2004) reported large variations in reproduction and production performance of local chickens in Tanzania. Recently Guni et al (2013) characterized selected local chickens from southern highlands of Tanzania.

In Kenya Okeno et al (2012) and Njenga et al (2005) revealed that farmers carry out chicken selection at household level based on growth rate, large body size, high egg production, hatchability and good mothering ability whereas farmers, marketers and consumers prefer the above mentioned traits as traits of economic importance and therefore should be given priority when developing breeding objectives for improvement of indigenous chicken. Magothe et al (2010) inferred that linear body measurements like shank length, drumstick length, drumstick circumference and chest circumference are easy to measure and suggested that these variables may be used to predict body weight of local chicken ecotypes especially under field conditions. (Olwande et al 2010) reported significant clutch sizes and hatchability rates in Kenya. Njenga et al (2005) reported the three major objectives of poultry rearing found to be for food, sale, and cultural uses and concentrated more on the hatchability so as to achieve the objectives.

Although the performances of local chicken ecotypes have been evaluated and documented in Kenya, data are scarce on key attributes and not all regions have been studied hence we collected data from previously unstudied areas. We looked at some morphological traits, reproductive and morphometric attributes and revealed that there are important differences within and between the local chicken populations with respect to egg production, reproductive attributes and morphometric attributes that were considered in the study. This suggested that there is room for selection within and between the local chicken ecotypes for both meat and egg production. We targeted regions with no previous poultry improvement programs and were also human and livestock domestication/migration corridors into Kenya hence harboring distinct local chicken ecotypes Aswani et al (2015) and Moraa et al (2015).

Materials and Methods

Study Area

The three agro-climatic zones chosen for this study were Lake Turkana basin arid area, Lamu archipelago semi arid coastal area and Mount Elgon catchment humid highland area. These were the preferred study sites since the areas sampled were not adversely affected by the cockerel and pullet exchange breeding program and they were routes of livestock domestication/migration corridors into Kenya (Mwacharo et al 2013). Mount Elgon catchment study area is a highland found in zone I, II and III of the agro-climatic zones of Kenya. These three zones are considered wet and they are characterized by an annual rainfall of 500-1000 mm per annum and an annual temperature of 17.1°C minimum and 29.4°C maximum (Jaetzold and Schmidt 1983). Lamu is semi arid area and it lies within zones IV and V of the agro-climatic zones, this zone is considered dry and humid and receives an annual rainfall of 800mm and an annual temperature of 24.1°C minimum and 29.2°C maximum. Turkana basin is arid, it lies within zone VI and zone VII of the agro- climatic zones of Kenya. These zones are characterized by annual rainfall of 200-600 mm which is quite unreliable since crops can hardly survive in this environment but livestock have adapted and they survive. It's also characterized by an annual temperature of 23.7°C and 34.9°C (Paron et al 2013). A map showing the study areas is shown in figure 1 while the specific counties from which data was collected are outlined in table l.

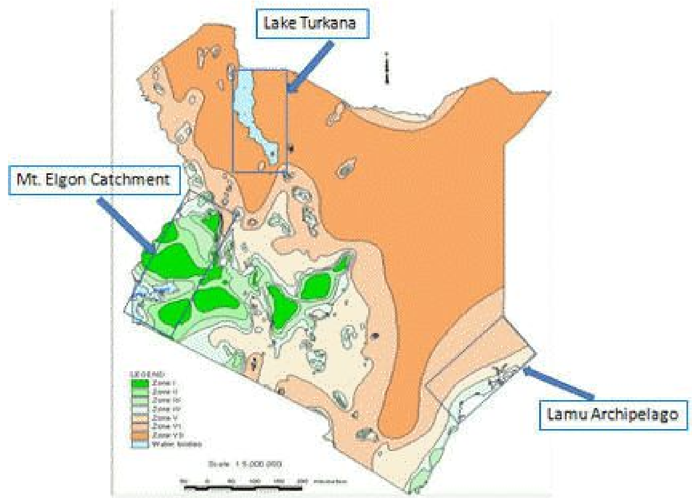

Figure 1. Map of study area. Source (http://www.infonet.biovision.org)

Table 1. Summary of sampled locations

Agro-climatic zones	Population	Number of samples	Feeding	Reproduction
Lake Turkana basin	Lake Turkana East	33	scavenging	Random mating
	Lake Turkana West	61	scavenging	Random mating
	Total	**94**	scavenging	Random mating
Lamu Archipelago	Lamu North	27	scavenging	Random mating
	Lamu central	30	scavenging	Random mating
	Lamu South	46	scavenging	Random mating
	Total	**103**	scavenging	Random mating
Mt. Elgon catchment	Mt. Elgon north	31	scavenging	Random mating
	Mt. Elgon south	44	scavenging	Random mating
	Lake Victoria	24	scavenging	Random mating
	Total	**99**	scavenging	Random mating
	Total samples	**296**	scavenging	Random mating

Data collection

Interviews were conducted at the farmers' homes with the assistance of local agricultural extension officers from the Ministry of Agriculture. Pre-tested questionnaire on open data kit (ODK) on phones were used to obtain the morphological and physiological data of the local ecotype chickens based on the production traits. Data was collected on a total of 296 genetically unrelated adult (above 1 year) local ecotype chickens from 10 populations each having 20-30 individuals according to (Hale et al 2012). Data was collected on various phenotypic attributes including the number of eggs laid per hen, colour of the eggs laid, eggs seated on per clutch per hen, eggs hatched per clutch per hen, number of yolks in each egg and sitting times per hen per year. Physical measurements like body weight, body length, shank length, were also taken using a measuring tape, vernier caliper and recorded as described by (FAO 2012). The weights of chickens were measured using portable sensitive weigh balance. The body weight was the individual live weight of the chicken. Body length was taken as the distance between the caudal (tail, exclusive of feathers) and tip of the rostrum maxillae (beak) when chicken was fully stretched while the shank length was measured from the spur to the hock joint of either leg according to (Adeleke et al 2011). A global positioning system (GPS) was used to record coordinates for the study sites.

Study clearance

This study got a no objection for the research under the permit number “RES/POL/VOL.XXVII/162” from the Ministry of Agriculture, Livestock and Fisheries state department of veterinary services.

Data analysis

Data was analyzed using R core statistics software version 3.0.1, Graph Pad Prism™ version 6.0 and Microsoft excel 2013. Significant differences within means were determined using Tukey’s test at 95% confidence level. We also used analysis of variance (ANOVA) tests to determine relationships between various production traits and the ecosystem.

Results and discussion

Analysis of Body Measurements (Body Length and Shank Length) In Indigenous Chickens from Different Agro-Climatic Zones

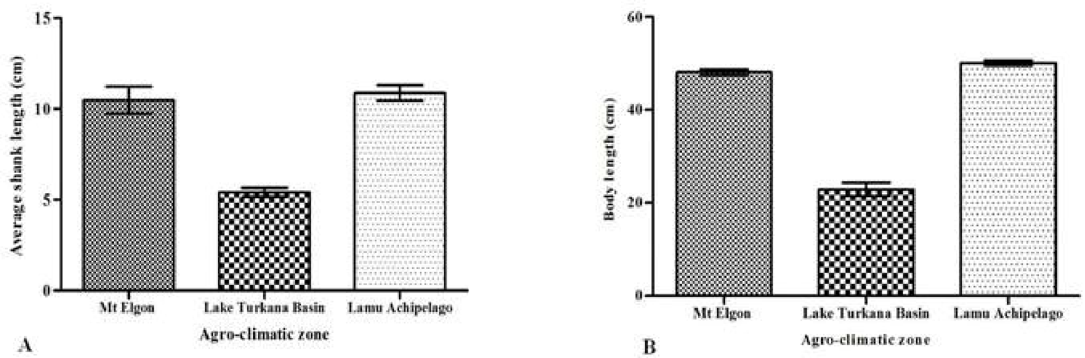

Figure 2. Average shank length (A) and body length (B) of chickens sampled in 3 agro-climatic zones of Kenya. Vertical bars represent standard deviation of the mean according to Tukey’s test at P<0.05

The average body lengths and shank lengths are outlined in figure 2 above. Chickens from Lamu archipelago were found to have the longest average shanks, followed by those from Mt Elgon while those from Lake Turkana recorded the shortest average shank (Figure 2A above). A similar pattern was observed for the body length of chickens in the agro-climatic zones. Chickens from Lamu Archipelago recorded the highest body lengths followed by those from Mt Elgon and Lake Turkana (Figure 2B above). The results differed from Guni et al (2013) who reported a range of 40.2cm and 45.7cm in body length. The observed variation in body length between agro-climatic zones indicates the existence of different diverse subpopulations within the local chicken ecotypes.

Analysis of Body Weight of Chickens Sampled in the Three Agro-Climatic Zones

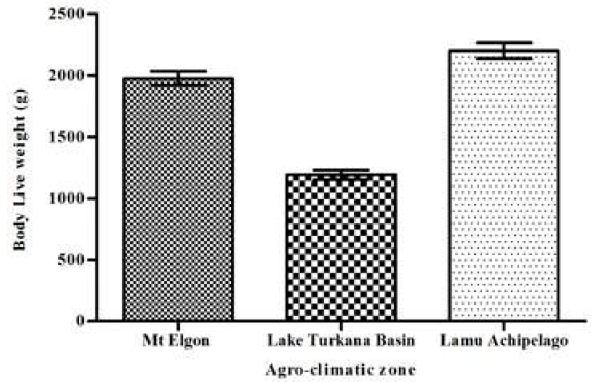

Figure 3. Analysis of average body weight of chickens sampled in 3 agro-climatic zones in Kenya. Vertical bars represent standard errors of the mean according to Tukey's test at P<0.05

Lamu archipelago recorded the heaviest chickens, based on body live weight, followed by Mt Elgon with Lake Turkana recording the lowest average weight (Figure 3 above). The average body weights(g) observed in the present study fell within the range of 1030 and 2860, 1108 and 2915 and 1525 and 2095 as reported by Katule (1998); Msoffe et al (2001); Guni et al (2013) respectively. However, the results were higher than the ones reported by Dana (2010); Olawunmi et al (2008); Mwalusanya et al (2002) and Guèye E F (1998). In Kenya, they were higher than the results reported by Magothe et al (2010) who reported a range of 1330.2-1741.0, slightly different from Olwande et al (2010) who reported a range of 1599g-2096 respectively though they were lower than the ones reported by King'ori (2004) who reported a range of 1950-3150.

We observed a significant variation in body weight between agro-climatic zones indicating the existence of different diverse subpopulations within the local chicken ecotypes.

Agro-climatic zones and the various traits: Shank length, body length and live weight

Table 2. ANOVA Summary results of analysis of agro-climatic zones and various traits attributed to body growth production in indigenous chickens of Kenya

Traits	*p*
Agro-climatic zones and Shank Length	***
Agro-climatic zones and Body Length	***
Agro-climatic zones and Live weight	***

*Significant codes: 0 '***' 0.001 '**' 0.01 '*' ns-not significant p<0.001*

Upon analysis of variance on the obtained data, there was a significant relationship between the shank length, body length and live weight and the agro-climatic zones (Table 2). The significant interaction between body weight and other body measurements imply that these easily measured parameters can be used for estimation of body weight and hence important in selection criteria that can be used to improve body weight. The existence of positive and significant correlations between body weight and body measurement traits have also been reported by Alabi and Ng`ambi (2012) and Guèye et al (1998) from Nigeria and Senegal respectively for local chickens.

Distribution of Production Traits Associated With Egg Production among Chickens in Different Agro-Climatic Zones

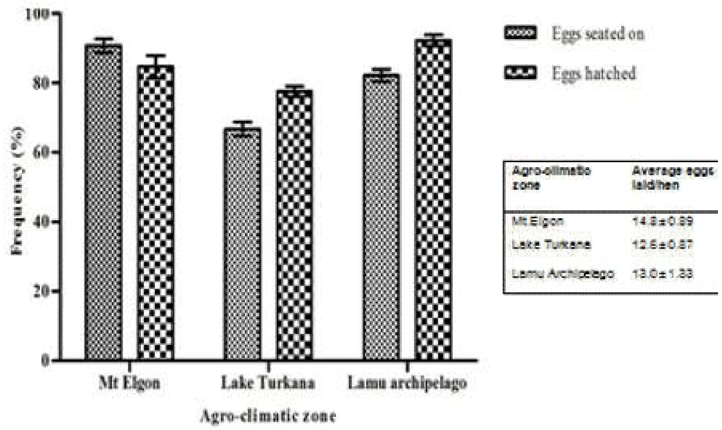

Figure 4. Comparison of frequencies of eggs seated on and eggs hatched in chicken sampled from 3 agro-climatic zones in Kenya.
Vertical bars represent standard errors of the mean according to Tukey's test at P<0.05.
The average number of eggs laid per hen in each zone are shown inset.

We found no significant differences between the agro-climatic zones with respect to this variable. These results were in consistent to those reported by Guni et al (2013) who reported 13.7 eggs. Mwalusanya et al (2002) and Olwande et al (2010) reported the mean clutch size to be 11.8 eggs and 11 eggs respectively, lower than the mean value reported in the study. We found out the frequencies of eggs sat on yearly showed a slight variation within the agro-climatic zones of Kenya. For instance, Mt Elgon catchment recorded the highest frequency of eggs seated on by the local ecotype chickens while Lake Turkana had the lowest frequency of eggs seated on at (Figure 4). The difference in the frequencies of eggs sat on was mainly based upon the farmers' decision to give out the eggs to the hens. We found out that the farmers give out a certain fraction to the hens to lay on and consume or sell the rest for cash. The results were confirmed with extension officers from the Ministry of Agriculture, livestock and fisheries who also keep records of livestock production.

Analysis of hatchability among the 3 zones similarly revealed slight differences in the frequencies of eggs hatched. We obtained high hatchability in Lamu archipelago followed by Mt Elgon and Lake Turkana at 84.6% and 77.62% respectively (Figure 4). These results were consistent with Guni et al (2013); Kugonza et al (2008); Njenga et al (Development and Veterinary 2005); Mammo et al (2008), who reported a hatchability of between 83.2% and 92.6% in chickens from different districts in Tanzania with an exception for Lake Turkana basin which had lower hatchability. In Kenya Olwande et al (2010); King'ori (2004); Okitoi and Mukisira (2001) reported lower results than the ones reported in this study as follows: 70%-80%, 43%-47% and 46%-48% respectively. The results were confirmed with extension officers from the Ministry of Agriculture, livestock and fisheries who also keep records of livestock production.

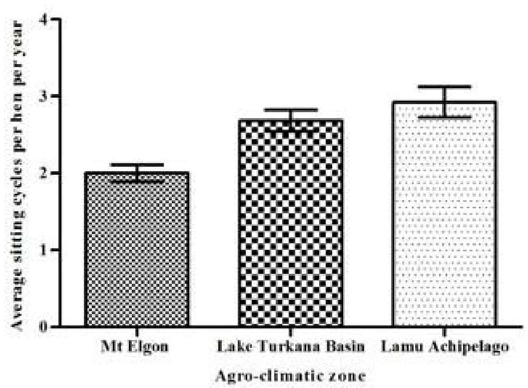

Figure 5. Average sitting cycles of indigenous chickens sampled from 3 agro-climatic zones of Kenya.
Vertical bars represent standard deviation of the mean according to Tukey's test at P<0.05

We further estimated the number of sitting cycles per hen per year. Results of the present study showed that Lamu archipelago had the highest average sitting cycles per hen per year followed by Lake Turkana basin and Mt. Elgon (Figure 5). We observed average mean number of 1.78 clutches per year in the present study was lower as compared to the ones that were reported from other studies in different countries such as Tanzania Guni et al (2013); Bangladesh Hossen (2010); Botswana Moreki, (2010); Namibia (Petrus, 2011) and India Iqbal and Pampori (2008). The latter reported a sitting cycle of four clutches per year.

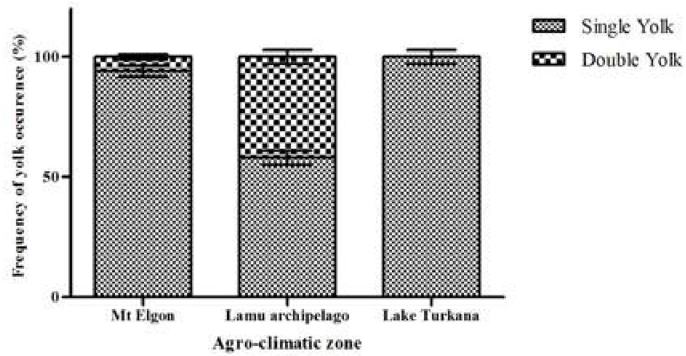

Figure 6. Analysis of the number of yolks per egg in chickens from 3 agro-climatic zones of Kenya.
Vertical bars represent standard deviation of the mean according to Tukey's test at P<0.05.

Lamu Archipelago had heavy-bodied chickens though they produced fewer eggs which were often double-yolked. The study found out that despite the fact that Local ecotype chickens in Lake Turkana basin were small but produced more eggs as compared to the ones in Lamu Archipelago which were heavy-bodied though they produced fewer eggs that were often double-yolked. Double yolk is a trait that possesses no selective advantage (Lowry, 1967).

Table 3. ANOVA Summary results of analysis of agro-climatic zones and various traits

Traits	*p*
Agro-climatic zones and number of yolk in an egg	**
Agro-climatic zones and number of eggs laid	ns
Agro-climatic zones and number of eggs sat on	ns
Agro-climatic zones and number of eggs hatched	ns
Agro-climatic zones and number of sitting times per year	**

*Significant codes: 0 '***' 0.001 '**' 0.01 '*' ns-not significant P<0.05*

We also sought to find out the existence of significant interactions between the numbers of eggs laid per clutch, sat on, hatched and the number of sitting times per year in different agro-climatic zones; the results are summarized in table 3. There is a significant relationship between the agro-climatic zones and the number of yolks in an egg and the number of sitting times per year at 95% confidence interval level. However, the study confirmed that there was no significant relationship between the agro-climatic zones and the number of eggs laid, number of eggs seated on and number of eggs hatched per hen per clutch.

Conclusions

- The study focused on local chicken ecotypes from regions which are historical migration routes for humans and livestock into Kenya and have not been widely studied.
- Our results show that these regions have distinct local chicken ecotypes that need to be conserved and incorporated in the Kenya National poultry breeding program.
- We recommend the local chicken ecotypes from Lamu especially the unique Kuchi breed to be developed for meat production and the local chicken ecotypes from lake Turkana basin for egg production.
- The obtained interactions between agro-climatic zones and the traits point towards a genetic influence within these populations.
- These could be harnessed and integrated into other local chicken ecotypes through the improvement of the national poultry breeding program in Kenya.

Implications

- Sampling at the natural ecological site was used in this study so as to investigate the local chicken ecotypes in their natural settings. We recommend on-station controlled experiments to study further the genetic potential of these chicken ecotypes.
- Findings from this study should direct further research to investigate the role of factors such as genetics, epigenetics, feed intake, disease status and appetite mostly in their natural ecological setting.

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