

QUANTITATIVE AND QUALITATIVE TRAITS CHARACTERISATION OF INDIGENOUS CHICKENS IN SOUTHERN AFRICAN COUNTRIES

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Supporting Information

ABSTRACT: Indigenous poultry production is important to human lives as they alleviate poverty by providing an affordable source of animal proteins. Besides, it serves as the easiest source of income for rural farmers in developing countries. The current review was conducted to evaluate the research findings of indigenous chickens' quantitative and qualitative traits characterisations in Southern African countries. Quantitative and qualitative traits characterisation is the first step for genetic improvement in livestock. The documents used in the review were attained from different search engines, most of which were published lately (after 2010). Potchefstroom Koekoek, Venda, Naked Neck, Ovambo, Boschveld and Tswana indigenous chicken breeds in the Southern African countries were characterised. The studies suggest that there are variations in quantitative traits including live weight, egg weight, wing length, comb length and shank length and qualitative traits including feather color, comb type, comb color and eggshell color of indigenous chickens of Southern African countries. The single red comb types and red wattles were observed in most indigenous chicken breeds in Southern African countries. The present review concludes that the characterisation of quantitative and qualitative traits assists greatly in the differentiation and identification of indigenous chicken breeds.

Keywords: Breed; Characterisation; Chickens; Quantitative traits; Qualitative traits.

INTRODUCTION

Poultry farming is the raising of poultry birds for the production of protein sources such as eggs and meat and it remains one of the vital enterprises among the underprivileged smallholder households in Africa (Ndegwa et al., 2014; Kamau et al., 2018). Indigenous chickens have special significance to the local community (Machete et al., 2021). These chickens have varied morphological characteristics and possess genes with adaptive values to their environment and local diseases (Aklilu et al., 2013). Often, the populations of indigenous chickens are differentiated and classified based on the geographical place or phenotypic features, whereas their categorization into genotypes is limited (Manyelo et al., 2020). In sub-Saharan countries, indigenous chickens generate about 80% of poultry production, with Nigeria being recognized as the country with the highest number of indigenous chickens (Desha et al., 2016).

According to Manyelo et al. (2020), indigenous chickens in Africa are hardy, well adapted to rural areas under scavenging conditions, can sustain themselves and survive with minor or no input of feeds and are disease resistant. According to Liswaniso et al. (2020), indigenous chickens contribute abundantly to the socio-economic status of people in rural communities as a source of good animal proteins for human nutrition and income for the households as well as for cultural practices. Indigenous chickens' meat is highly preferred because of its nutritious pleasant taste over exotic chicken genotypes (Mengesha, 2012).

Poultry products, namely eggs and meat, have been recognized as the finest source of affordable and quality protein, particularly to those people experiencing malnutrition difficulties in Sub-Saharan Africa (Kamau et al., 2018). Mengesha (2012) indicated that shortages in the obtainability of protein are the main concern in Africa. Indigenous chickens have poor production performance in meat and eggs because of their reduced genetic potential (Mengesha and Tsega, 2014). Also, loss of local genetic resources of chickens is experienced because of poor management of the indigenous chicken breeds, which leads to mortalities (Siyaya and Masuku, 2013). Lack of access to the nearby market, extension services, high cost of feeds and lack of education and knowledge of local chicken farmers are issues that might negatively influence the productivity of local chicken production (Natukunda et al., 2011). Numerous studies were done previously to characterize the indigenous chickens based on their phenotypic characteristics (Aklilu et al., 2013; Mengesha and Tsega, 2014; Singh et al., 2014; Reddy et al., 2015; Agarwal et al., 2020; Machete et al., 2021) to improve their production performances.

However, based to our knowledge, there is no documented study combining the information on the quantitative and qualitative traits characterisation of indigenous chickens in Africa.

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Hence, the objective of this review was to document the research findings of indigenous chickens' characterisations, thus, provide information to farmers for breeding to improve indigenous chicken production strategies. Therefore, reviewing the research outcomes will also allow the provision of useful information that will assist in the future planning to advance native chicken production projects of Africa.

METHODS

The current review was conducted in agreement with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher et al., 2009). Several research outcomes that have a relation with indigenous chickens in South African countries were reviewed, shown and referenced. Reports of studies that focused on the characterisation of indigenous chickens were reviewed as well. The search was done using search engines such as Google, Yahoo and Baidu and databases such as Google Scholar, Semantic Scholar, Science Direct and PubMed. During the search process, the keywords used were indigenous chickens, chicken characteristics, quantitative and qualitative traits. Studies were considered for inclusion in the review provided, they dealt with indigenous chickens and their phenotypic characterisation. Research outcomes on the genetics of indigenous chickens were also considered for inclusion in some sections of the review.

RESULTS

Origin of Southern African Indigenous chickens

Africa comprises numerous indigenous chicken breeds, which have a less productivity of egg and meat (Sil et al., 2002). Indigenous chickens are recognised as a gene pool for significant traits including adaptability, hardiness and disease resistance (Alabi et al., 2012). According to Grobbelaar et al. (2010), their different carcass color, the toughness of the muscle meat, shell color and yolk color are preferred by most consumers. The indigenous chicken breeds common in the Southern African region include Potchefstroom koekoek, Venda, Ovambo, Naked neck and Boschveld (Mtileni et al., 2012; Idowu et al., 2018). Another African local breed includes Tswana chicken.

Potchefstroom Koekoek chicken breed

Potchefstroom Koekoek (Figure 1) is an indigenous chicken breed that was produced in the 1950s in Potchefstroom Agricultural College by a researcher, Marais, and it is a crossbred of White Leghorn, Black Australorp and barred Plymouth (Grobbelaar et al., 2010). The Koekoek name refers to the barred color pattern of the chicken. Potchefstroom Koekoek is a dual-purpose chicken breed reared for meat and egg production; it is highly adapted to free-range conditions (Dessie et al., 2011). It performs better than all the other indigenous chickens in South Africa (Heit, 2017).



Figure 1 - Potchefstroom Koekoek chicken breed



Figure 2 - Venda chicken breed

Venda chicken breed

According to Norris and Ng'ambi (2006), the Venda chicken breed was discovered in Venda in the Limpopo province, South Africa, by the veterinarian, Dr Naas Coetzee, in 1979. The breed was named after its origin. Venda chicken breed (Figure 2) is multicolored with predominating colors as black, white and red. The breed is used for egg and meat production; the hens have good mothering ability and broodiness. They can survive well in harsh environments with minimum additional feed and are highly disease resistant (Ng'ambi et al., 2013).

Naked Neck chicken breed

The Naked Neck chicken (Figure 3) is an African breed believed to have originated in Malaysia (Mtileni et al., 2011). Naked Neck chickens are divided into two types namely, purebred which has a fully naked neck and the one with a tassel on the front part of the neck, which is not purebred (Kingori et al., 2014). The chicken has a diversity of color designs, which help camouflage to protect them from ground predators (Amao, 2017). Naked Neck chickens can sustain themselves through scavenging for food and are well adapted to adverse conditions (Manyelo et al., 2020).

Ovambo chicken breed

Ovambo is a small chicken breed that originated in the northern part of Namibia and Ovamboland in Africa. It is a dual-purpose breed reared for meat and egg production (Grobbelaar and Fourie, 2006). Ovambo breed (Figure 4) is considered as being aggressive because of its ability to capture and feed on young rats and mice. They can fly and climb on top of the trees to run away from predators at night and they can also survive in harsh environments and sustain themselves (Grobbelaar et al., 2010).



Figure 3 - Naked Neck chicken breed



Figure 4 - Ovambo chicken breed

Boschveld chicken breed

According to Bosch (2011), the Boschveld chicken breed (Figure 5) is a crossbred of Venda, Ovambo and Matebele breeds. It was developed in Mantsole ranch in Limpopo province, South Africa, in 1998. The breed can perform well under free-range system and in scavenging situations for survival; it also possesses disease-resistant traits. The hens are good brooders and have good mothering ability. It is reported that 50% of the traits were inherited from the Venda breed by Boschveld chicken, 25% from the Ovambo breed and 25% from the Matebele breed (Manyelo et al., 2020). Boschveld chicken is a dual-purpose breed mainly bred for meat and egg production (Okoro et al., 2017).

Tswana chicken breed

Tswana chicken (Figure 6) is an indigenous breed that originated in Botswana and is the most widely spread domestic animal, which almost every rural family owns in Botswana. The Tswana chickens contribute more to rural households by providing meat and eggs for human consumption (Machete et al., 2021). They are categorised into five strains namely dwarf, naked neck, frizzled, rumples and normal, with the most common strain being the normal (Machete et al., 2017). Tswana chickens have good self-sustainment, and they are usually reared under an extensive farming system where they scavenge for feed and feed on insects with little or no feed supplementation (Badubi et al., 2006). These indigenous chickens can produce meat and eggs with minimal management (Magpantay et al., 2016).



Figure 5 - Boschveld chicken breed



Figure 6 - Tswana chicken breed

Table 1 - Quantitative traits of Southern African indigenous chicken breeds

Chicken breed	LW (kg)	EW (g)	WL (cm)	CL (cm)	BL (cm)	SL (cm)	References
Potchefstroom Koekoek	4.50	55.80	5.50	5.90	43.33	29.33	(Alabi et al., 2012; Makhafola et al., 2012; Dessie and Gatachew, 2016)
Venda	3.6	53.00	21.00	5.80	45.50	30.00	(Alabi et al., 2012; Ng'ambi et al., 2013)
Naked Neck	3.50	55.50	21.50	5.40	45.00	32.50	(Alabi et al., 2012; Makhafola et al., 2012)
Ovambo	2.16	52.50	14.50	5.80	24.50	8.30	(Bett et al., 2013; Makhafola et al., 2012; Mngonyama, 2012)
Boschveld	2.60	53.40	20.00	5.32	23.70	9.79	(Dessie et al., 2011; Petrus et al., 2019)
Tswana	2.56	49.95	20.61	6.30	22.40	9.94	(Kgwatalala et al., 2012; Kgwatalala et al., 2013; Machete et al., 2017)

LW: Live weight, AEW: Egg weight, WL: Wing length, CL: Comb length, BL: Body length and SL: Shank length

Table 2 - Qualitative traits of Southern African indigenous chicken breeds

Chicken breed	Feather color	Comb type	Comb color	Egg shell color	References
Potchefstroom Koekoek	Black and white	Single	Red	Brown	(Magothe et al., 2012; Heit, 2017)
Venda	Black, white and black	Single	Red	Tinted	(Ng'ambi et al., 2013)
Naked neck	Red, blue, buff, white and black	Single	Red	Light brown	(Grobbelaar et al., 2010; Amao, 2017)
Ovambo	Black, white and orange	Single	Red	Brown	(Grobbelaar et al., 2010)
Boschveld	Light red-brown and white	Single	Red	Brown	(Bosch, 2011)
Tswana	Black, brown, grey and white	Single	Red	Cream white-light brown	(Machete et al., 2021; Kgwatalala et al., 2013)

Quantitative characterisation of Southern African Indigenous chickens

The quantitative characterisation of the selected Southern African indigenous chickens is presented in Table 1.

Potchefstroom Koekoek chicken breed

Potchefstroom Koekoek breed is heavy, the roosters weigh about 1.84 kg at 16 weeks of age, 2.4 kg at 20 weeks and about 3.5 kg to 4.5 kg at maturity while hens can weigh around 1.4 kg at 16 weeks, 1.7 kg at 20 weeks and 3.5 kg at maturity (Dessie and Gatachew, 2016). The sexual maturity of Potchefstroom Koekoek is at 130 days, with the hens being able to lay an average of 198 eggs per annum and the eggs are large, with an average weight of 55.78 grams (Mtileni et al., 2012). Tyasi et al. (2020) reported that the average body measurements of Potchefstroom Koekoek chicken hens at 22 weeks for wing length, back length, beak length, shank length, shank circumference, chest circumference, keel length, body girth, toe length and body length were noted as 4.70, 0.49, 0.22, 8.17, 4.69, 26.56, 11.22, 36.83, 6.28 and 33.15 cm, respectively. Alabi et al. (2012) reported that male chickens grow faster than females. The average body measurements of male Potchefstroom Koekoek chickens at 22 weeks of age for body length, body girth, wing length and shank length were noted as 43.33, 19.67, 5.50 and 29.33 cm, respectively. The comb length and wattle length measurements were found to be 5.9 and 5.6 cm, respectively (Makhafola et al., 2012).

Venda chicken breed

Venda chicken is a fairly large breed, at 16 weeks of age, the roosters are weighing about 1.57 kg, 2.01 kg at 20 weeks and when they reach maturity, they weigh about 2.9 kg to 3.6 kg. At 16 weeks of age, the hens are weighing about 1.24 kg, 1.4 kg at 20 weeks and when they mature, they weigh about 2.4 kg to 3 kg (Ng'ambi et al., 2013). The Venda chicken hen reaches maturity at 143 days and can lay large eggs of roughly 129 eggs per annum and average egg weight of 53 g (Grobbelaar et al., 2010). The average body measurements of male Venda chickens at 22 weeks of age for body length, body girth, wing length, comb length, shank length and shank thickness were found to be 45.50, 42.50, 21.00, 5.8, 30.00 and 4.75 cm, respectively. The females were found to measure 38.40, 35.20, 18.00, 25.60 and 4.05 for body length, body girth, wing length, shank length and shank thickness, respectively (Alabi et al., 2012).

Naked Neck chicken breed

Naked Neck chicken is categorized as a massive breed. At 16 weeks of age, the roosters weigh about 1.5 kg, 1.95 kg at 20 weeks and at maturity, they weigh about 3.5 kg. At 16 weeks of age, the hens weigh around 1.1 kg, 1.4 kg at 20 weeks and 3 kg at maturity. The chicken breed reaches sexual maturity at 155 days and yields eggs with an average weight of 55.5 g. Alabi et al. (2012) reported that the average body measurements of male Naked neck chickens at 22 weeks of age for body length, body girth, wing length, shank length and shank thickness were found to be 45.00, 41.00,

21.50, 32.50 and 5.50 cm, respectively. The female chicken's body measurements were found to be 38.90, 35.30, 17.20, 25.70 and 4.00 cm for body length, body girth, wing length, shank length and shank thickness, respectively. The comb length and wattle length measurements were found to be 5.4 and 5.6 cm, respectively (Makhafola et al., 2012).

Ovambo chicken breed

Ovambo chicken is a lightweight breed, at 16 weeks of age, the roosters weigh about 1.74 kg and 2.16 kg at 20 weeks. At 16 weeks, the hens weigh about 1.32 kg and 1.54 kg at 20 weeks. The birds reach sexual maturity 143 days old. The hens yield 129 eggs per annum, with an average weight of 52.5 g per egg (Bett et al., 2013). Makhafola et al. (2012) found that the shank length, comb length and wattle length average measurements at maturity were 8.3, 5.8 and 6.0 cm, respectively. The measurements of head length, head width, comb height, beak length, body length, neck length, wing length and keel length at maturity were noted as 5.08, 3.51, 3.82, 1.75, 24.5, 1.79, 14.5 and 14.4 cm, respectively (Mngonyama, 2012).

Boschveld chicken breed

According to Dessie et al. (2011), the Boschveld chicken breed is large. At 12 weeks of age, the roosters weigh about 1.6 kg and 2.6 kg at 20 weeks while at 12 weeks, the hens weigh 1.5 kg and 1.7 kg at 20 weeks. Sexual maturity is reached at 136 days of age by the birds. Each hen produces about 4 eggs in a week and an average of 200 eggs in a year, with an average egg weight of 53.4 g. According to Petrus et al. (2019), Boschveld chicken hens average body measurements at 18 weeks of age for shank length, wing length, body length, chest girth, beak length, comb length, neck length and keel length were found to be 9.79, 20.00, 23.70, 30.40, 3.78, 5.32, 18.70 and 11.64 cm, respectively.

Tswana chicken breed

Tswana indigenous chicken is a large breed with males weighing an average live weight of 2.56 kg and females weighing 2.02 kg at maturity (Machete et al., 2017). The average body measurements of male Tswana chickens are higher than of females, which indicate that males grow faster than females (Kgwatalala et al., 2012). In males, the shank length, shank circumference, spur length, wingspan, wing length, body length, comb length and wattle length measures 9.94, 0.99, 1.19, 41.22, 20.61, 22.40, 6.30 and 3.44cm, respectively. In females, the shank length, shank circumference, spur length, wingspan, wing length, body length, comb length and wattle length measures 8.35, 0.84, 0.35, 37.19, 18.60, 20.91, 3.48 and 2.40 cm, respectively (Machete et al., 2017). The hens can lay between 180 and 200 eggs in a year with an average egg weight of 49.95 g, egg length of 5.68 cm and egg width of 4.23 g (Kgwatalala et al., 2013).

Qualitative characterisation of Southern African indigenous chickens

The qualitative characterisation of the selected Southern African indigenous chickens is presented in Table 2.

Potchefstroom Koekoek chicken breed

The Potchefstroom Koekoek is characterised by its black-and-white striped soft feathers and yellow legs as shown in Figure 1 and it is also having yellow attractive skin color (Magothe et al., 2012). The wattle is red colored, large in cocks and small in hens. This chicken breed lays brown shelled eggs with rich yellow to orange yolk colors and it is also having a single comb type, which is red (Heit, 2017).

Venda chicken breed

Venda chicken breed has multi-colored soft feathers with black, white and red as predominating colors. The chicken breed is having a single rose-colored comb type, which is red and five-toed feet, beards or crests are common. Venda chickens lay large and tinted eggs (Ng'ambi et al., 2013). The cocks have a large red wattle when compared to hens with small-sized red wattle (Grobbelaar and Fourie, 2006).

Naked Neck chicken breed

The Naked neck chicken breed common feather colors are known as red, blue, buff, white and black. The chicken breed has about 30% fewer feathers than other chicken breeds and they lay a respectable number of eggs with light brown shells (Grobbelaar et al., 2010). Naked neck chickens carry a large single comb and the skinned neck, earlobes and the heads are dazzling red. The neck of this chicken breed is featherless to the upper breast; the wattle is large with a red coloration and these chickens have large, four-toed feet and reddish to bay-colored eyes (Amao, 2017). This chicken breed has a plain head, highly developed wattles in males and medium-size wattles in females (Mammo et al., 2008).

Ovambo chicken breed

The Ovambo chicken breed has feathers of a dark to black color, with stripes of white and or orange. The varying color patterns help them to camouflage for protection from their predators (Grobbelaar et al., 2010). The chicken breed has a single red colored comb, which is large in cocks when compared to hens as shown in Figure 4 above. The cocks have highly developed hanging red wattle while the hens are having a small-sized red wattle (Van Marle-Köster and Casey, 2001).

Boschveld chicken breed

The Boschveld chicken has a light red-brown color with white feathers in-between that assists to camouflage and defend them from predators. The hens can lay medium brown shelled eggs and they have a single comb type, which is red colored (Bosch, 2011).

Tswana chicken breed

Tswana chickens have varying plumage colors with normal chicken strains being most common with varying plumage color frequencies. The body has black, brown, grey and white colors with the tail having 60.5% black, 23.3%

brown, 11.5% grey and 4.7% white plumage colors. The breast plumage has 44.2% brown, 41.9% black, 7.0% grey and 4.7% white colors, the back plumage has 46.5% brown, 37.2% black, 9.3% grey and 4.7 white and neck has 22% brown, 15% black, 4% white and 3.1% grey plumage colors (Figure 6). The normal Tswana chicken has a single comb type, plain head shape and red earlobes color. The breed has 67.4% featherless shank and 36.4% feathered shank and 55.8% blue, 34.9% khaki, 7.0% yellow and 2.3% grey shank color (Machete et al., 2021). The hens can lay cream white to light brown eggs (Kgwatalala et al., 2013).

CONCLUSION

This review has provided information on the characterisation and importance of local chickens in African livelihoods. The review focused on local chicken breeds in the Southern African region. Only fewer indigenous chickens have been classified into breeds. Often, they are differentiated and classified based on the geographical area or phenotypic features. The discoveries showed that there is variation in the feather colors, live weights and morphological traits measurements of the local chickens. The characterisation of quantitative and qualitative traits plays an important part in the differentiation and identification of local chicken breeds. The quantitative traits also assist in the understanding of growth patterns and egg production performance of the chickens. However, not much work was done on the qualitative traits characterisation of local chickens in the Southern African countries, hence, more studies need to be done on the characterisation of local chickens based on their qualitative traits.

DECLARATIONS

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Authors' contribution

V.R. Hloko performed conceptualization, writing, original draft preparation, review and editing. T.L. Tyasi performed conceptualization and evaluation of the manuscript before submission.

Conflict of interests

The authors declare that there is no conflict of interest.

REFERENCES

- Agarwal S, Prasad S, Kumar R, Naskar S, Kumari N, Chandra S and et al. (2020). Phenotypic characterisation and eco-nomic traits of native chicken of Chotanagpur plateau of Jharkhand. *Journal of Entomology and Zoology Studies*, 8: 2328-2333. <https://www.entomoljournal.com/archives/?year=2020&vol=8&issue=5&ArticleId=7822>
- Akliu E, Kefelegn K, Tadelle D and Banerjee AK (2013). Phenotypic characterisation of indigenous chicken population in Ethiopia. *International Journal of Interdisciplinary and Multidisciplinary Studies*, 1(1): 24-32. <https://www.researchgate.net/publication/316644827>
- Alabi OJ, Ng'ambi JW, Norris D and Egena SSA (2012). Comparative study of three indigenous chicken breeds of South Africa: Body weight and linear body measurements. *Agricultural Journal*, 7: 220-225. DOI: <http://dx.doi.org/10.3923/aj.2012.220.225>
- Amao SR (2017). Egg production and growth performance of Naked Neck and Rhode Island Red crosses under Southern Guinea Savanna condition of Nigeria. *International Journal of Agricultural Sciences*, 3(2): 2489-0081. <https://www.iiardjournals.org/get/IJAES/VOL.%203%20NO.%202%202017/EGG%20PRODUCTION.pdf>
- Badubi SS, Rakereng M, Marumo M (2006). Morphological characteristics and feed resources available for indigenous chickens in Botswana. *Livestock Research for Rural Development*, 18: Article #3. <http://www.lrrd.cipav.org.co/lrrd18/1/badu18003.htm>
- Bett HK, Peters KJ, Nwankwo UM and Bokelmann W (2013). Estimating consumer preferences and willingness to pay for the underutilized indigenous chicken products. *Food Policy*, 41: 218-225. DOI: <https://doi.org/10.1016/j.foodpol.2013.05.012>
- Bosch M (2011). *Farmers Weekly for Boschveld free range chickens*. <https://boschveld.co.za>
- Desha NH, Bhuiyan MSA, Islam F and Bhuiyan AKFH (2016). Non-genetic factors affecting growth performance of indigenous chicken in rural villages. *Journal of Tropical Resources and Sustainable Science*, 4: 122-127. DOI: <http://dx.doi.org/10.47253/jtrss.v4i2.620>
- Dessie T, and Gatachew F (2016). The Potchefstroom Koekoek breed. *International livestock research institute*. <https://cgspace.cgiar.org/handle/10568/72964>
- Dessie T, Taye T, Dana N, Ayalew W and Hanotte O (2011). Current state of knowledge on phenotypic characteristics of indigenous chickens in the tropics. *World's Poultry Science Journal*, 67: 507-516. DOI: <https://doi.org/10.1017/S0043933911000559>
- Grobbelaar J and Fourie C (2006). *How to Start a Poultry Farm*, Agricultural Research Council, Pretoria, South Africa, pp. 29-30. <https://www.yumpu.com/en/document/read/4392558/how-to-start-a-poultry-farm-ubisi-mail-magazine>
- Grobbelaar JAN, Sutherland B and Molalagotla NM (2010). Egg production potentials of certain indigenous chicken breeds from South Africa. *Animal genetic resources*, 46: 25-32. DOI: <http://dx.doi.org/10.1017/S2078633610000664>
- Heit HL (2017). A comparative study on the growth rates between outbred and inbred chickens. *International Livestock Research Institute*. 2017. [Article link](#)
- Idowu PA, Mpayiphele M and Muchenje V (2018). Practices, housing and diseases within indigenous poultry production in Eastern Cape, South Africa. *Journal of agricultural science*, 10: 111-121. DOI: <http://dx.doi.org/10.5539/jas.v10n11p111>

- Kamau CN, Kabuage LW and Bett EK (2018). Impact of improved indigenous chicken breeds on productivity. The case of small-holder farmers in Makueni and Kakamega counties, Kenya. *Cogent Food and Agriculture*, 4: 147. DOI: <https://doi.org/10.1080/23311932.2018.1477231>
- Kgwatalala PM, Bolowe AM and Pene T (2013). Laying performance and egg traits of indigenous Tswana chickens under traditional management. *Global Advanced Research Journal of Agricultural Science*, 2: 148-152. http://gari.org/ga_rjas/index.htm
- Kgwatalala PM, Nogayagae M and Nsoso SJ (2012). Growth performance of different strains of indigenous Tswana chickens under intensive management system. *African Journal of Agricultural Research*, 7: 2438-2445. DOI: <https://doi.org/10.5897/AJAR11.1220>
- Kingori AM, Wachira AM and Tuitoek JK (2014). Influence of energy intake on egg Production and weight in indigenous chickens of Kenya. *International Journal of Poultry Science*, 13: 151-155. DOI: <https://dx.doi.org/10.3923/ijps.2014.151.155>
- Liswaniso S, Ning Q, Xuesong S, Chimbaka IM, Xue S and Rifu X (2020). Quality Characteristics, Phenotypic correlations and Principal Component Analysis of Indigenous Free-Range Chicken Eggs in Lusaka; Zambia. *International Journal of Agricultural Research*, 6: 29-35. DOI: <http://dx.doi.org/10.5281/zenodo.3633577>
- Machete JB, Kgwatalala PM, Nsoso SJ, Moreki JC, Nthoiwa PG and Aganga AO (2021). Phenotypic characterisation (qualitative traits) of various strains of indigenous Tswana chickens in Kweneng and Southern districts of Botswana. *International Journal of Livestock Production*, 12: 28-36. DOI: <https://doi.org/10.5897/IJLP.2020.0745>
- Machete JB, Nsoso SJ, Kgwatalala PM, Moreki JC and Aganga AO (2017). Phenotypic characterisation of Tswana chickens based on quantitative traits in Kweneng and Southern Districts, Botswana. *Livestock Research for Rural Development*, 29: Article #132. <http://www.lrrd.org/lrrd29/7/jmsm29132.html>
- Magothe T, Okeno T, Muhuyi W and Kahli A (2012). Indigenous chicken production in Kenya: I. Current status. *World's Poultry Science Journal*, 68: 119-132. DOI: <https://doi.org/10.1017/S0043933912000128>
- Magpantay VA, Supangco EP, Pacificador AY, Sevilla CC, Lambio AL and Gayeta EC (2006). Characterisation of native chicken production system in a coconut-based farming system in Dolores, Quezon. *Philippine Journal of Veterinary Medicine and Animal Sciences*, 32: 195-202. <https://ejournals.ph/article.php?id=8809>
- Makhafola MB, Umesiobi DO and Nedambale TL (2012). Relationship between phenotypic and sperm traits of South African in-digenous cockerels. *International Journal of Livestock Production*, 3: 61-65. <https://academicjournals.org/journal/IJLP/article-full-text-pdf/5CD38241816>
- Mammo ME, Tamir B and Tadlele D (2008). Village Chicken Characteristics and Their Seasonal Production Situation in Jamma District, South Wollo, Ethiopia. *Livestock Research for Rural Development*, 20: Article #128. <http://www.lrrd.org/lrrd20/7/meng20109.htm>
- Manyelo TG, Seleledi L, Hassan ZM and Mabelebele M (2020). Local chicken breeds of Africa: Their description, uses and conservation methods. *Animals*, 10: 2257. DOI: <http://dx.doi.org/10.3390/ani10122257>
- Mengesha M (2012). Indigenous chicken production and the innate characteristics. *Asian Journal of Poultry Science*, 6: 56-64. DOI: <http://dx.doi.org/10.3923/ajpsaj.2012.56.64>
- Mengesha M and Tsega W (2014). Phenotypic and genotypic characteristics of indigenous chickens in Ethiopia: A review. *African Journal of Agricultural Research*, 6: 5398-5404. DOI: <http://dx.doi.org/10.5897/AJAR11.434>
- Mngonyama MBA (2012). Morphometric characteristics and consumer acceptability of meat from Potchefstroom Koekoek, Black Australorp, Venda and Ovambo chickens. MSc thesis, University of KwaZulu-Natal, Pietermaritzburg, South Africa. https://ukzn-dspace.ukzn.ac.za/bitstream/handle/10413/10127/Mngonyama_Mandisa_Bongeka_Acquilla_2012.pdf?sequence=1&isAllowed=y
- Moher D, Liberati A, Tetzlaj J, Altman DG, Altman D, Antes G, et al. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *Journal of Clinical Epidemiology*, 62: 1006-1012. DOI: <https://doi.org/10.1374/journal.pmed.1000097>
- Mtleni BJ, Muchadeyi FC, Maiwashe A, Chimonyo M and Dzama K (2012). Conservation and utilization of indigenous chicken genetic resources in Southern Africa. *World's Poultry Science Journal*, 68: 727-748. DOI: <https://doi.org/10.1017/S0043933912000852>
- Mtleni BJ, Muchadeyi FC, Maiwashe A, Groeneveld E and Groeneveld LF (2011). Diversity and origin of South African chickens. *Journal of Animal Breeding and Genetics*, 128: 209-218. DOI: <http://dx.doi.org/10.3382/ps.2011-01505>
- Natukunda K, Kugonza DR and Kyarisiima CC (2011). Indigenous chickens of the Kamuli Plains in Uganda: II. Factors affecting their marketing and profitability. *Livestock Research and Rural Development*, 23: 221. <http://www.lrrd.org/lrrd23/10/natu23221.htm>
- Ndegwa JM, Mead R, Norrish P, Shepherd DD, Kimani CW, Wachira AM, et al. (2014). Investigating eggs hatch-ability in indigenous chicken system with smallholder farms in Kenya in a participatory research using analysis of variation. *Journal of Applied Biosciences*, 80: 7000-7013. DOI: <http://dx.doi.org/10.4314/jab.v80i1.6>
- Ng'ambi JW, Thamaga MW, Norris D, Mabelebele M and Alabi OJ (2013). Effects of egg weight on hatchability, chick hatch-weight and subsequent productivity of indigenous Venda chickens in Polokwane, South Africa. *South African Journal of Animal Science*, 43: 0375-1589. DOI: <http://dx.doi.org/10.4314/sajas.v43i5.13>
- Norris D and Ng'ambi JW (2006). Genetic parameter estimates for body weight in local Venda chickens. *Tropical Animal Health and Production*, 38: 605-609. DOI: <http://dx.doi.org/10.1007/s11250-006-4420-6>
- Okoro VMO, Ravuhali KE, Mapholi TH, Mbajjorgu EF and Mbajjorgu CA (2017). Effect of age on production characteristics of Boschveld indigenous chickens of South Africa reared intensively. *South African Journal of Animal Science*, 47: 157-167. DOI: <http://dx.doi.org/10.4314/sajas.v47i2.7>
- Petrus NP, Kangootui K, Kandiwa E, Madzingira O and Mushonga B (2019). Relationship of age and live weight to linear body traits in female intensively reared Boschveld chicken in Namibia. *International Journal of Poultry Science*, 18: 483-491. DOI: <https://dx.doi.org/10.3923/ijps.2019.483.491>
- Reddy MV, Preetam VC, Reddy AR, Kumar UR, Reddy VR, Gautham K, Hareesh D and Vishnu PG (2015). Phenotypic characterisation of Indian Naked Neck chicken under tropical climatic conditions. *Asian Journal of Animal and Veterinary Advances*, 10: 527-536. DOI: <https://doi.org/10.3923/AJAVA.2015.527.536>
- Sil GC, Das PM, Islam MR and Rahman MM (2002). Management and disease problems of cockerels in some farms of Mymensingh, Bangladesh. *International Journal of Poultry Science*, 1: 102-105. DOI: <http://dx.doi.org/10.3923/ijps.2002.102.105>
- Singh EMH, Sisaye T and Johansson AM (2014). Phenotypic characterisation of indigenous chicken population in South West and South Part of Ethiopia. *British Journal of Poultry Science*, 3: 15-19. [https://idosi.org/bjps/3\(1\)14/3.pdf](https://idosi.org/bjps/3(1)14/3.pdf)
- Siyaya BJ and Masuku MB (2013). Determinants of profitability of indigenous chickens in Swaziland. *Journal of Business Economics and Research*, 3: 205. DOI: <http://dx.doi.org/10.5296/ber.v3i2.4346>

Tyasi TL, Makgowo KM, Mokoena K, Rashijane LT, Mathapo MC, Danguru LW, et al. (2020). Multivariate adaptive regression splines data mining algorithm for prediction of body weight of Hy-line silver brown commercial layer chicken breed. *Advances in Animal and Veterinary Sciences*, 8(8): 794-799. http://nexusacademicpublishers.com/uploads/files/AAVS_8_8_794-799.pdf

Van Marle-Köster E and Casey NH (2001). Phenotypic characterisation of native chicken lines in South Africa. *Animal genetic resources*, 29: 71-78. DOI: <https://doi.org/10.1017/S1014233900001425>