

Original Research Paper

# Phenotypic Characterisation of South African Unimproved Indigenous and Tankwa Goats

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## Article history

Received: 09-06-2019

Revised: 18-09-2019

Accepted: 23-10-2019

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**Abstract:** The aim of this study was to characterise and compare phenotypic characteristics of South African unimproved indigenous and Tankwa goats. Phenotypic characteristics of 44 South African unimproved indigenous and 41 Tankwa goats were assessed. The qualitative characteristics were assessed through visual appraisal. Quantitative characteristics such as body measurements were obtained using a flexible tape, while body weight was determined by using a weighing scale and body temperature with a thermometer. Body condition score of South African unimproved indigenous goats (98%) was more satisfactory when compared to that of Tankwa goats (74%). None of the Tankwa goats had ticks under their tails while 53% of South African unimproved indigenous goats had them. Most of the Tankwa goats had single or two colours as their main colours. Both goats' types had high proportion of moderate necks, brown eyes, average eye width and mouth shape. Tankwa goats' horns and hooves were more damaged when compared to those of South African unimproved indigenous goats. Tankwa goats had higher phenotypic characteristics (quantitative) with the exception of body temperature. In conclusion, qualitative characteristics were comparable between South African unimproved indigenous and Tankwa goats. However, quantitative characteristics of Tankwa goats were higher, with the exception of body temperature.

**Keywords:** Body Description, South African Indigenous Goats

## Introduction

South African indigenous goats such as Nguni, Kalahari Red, Savannah and Tankwa (Ramsay and Donkin, 2000; Kotze *et al.*, 2014) are tolerant to different parasites and diseases and are able to survive harsh environments (Pieters, 2007; Kotze *et al.*, 2014). However, some are poorly managed, with limited information on their performance and are under threat of extinction (Webb *et al.*, 1998; Kotze *et al.*, 2014). Extinction of these valuable assets is due to a combination of genes (Visser *et al.*, 2004; Mara *et al.*, 2013), which is caused by increased uncontrolled

breeding and the introduction of exotic breeds (Nsoso *et al.*, 2004; Esquivelzeta *et al.*, 2011). According to Roosen *et al.* (2005); Food and Agriculture Organization (2007; 2013), it has been estimated that 22 to 28% of farm animal breeds became eroded or threatened in the past century and this figure is now expected to be escalating. Therefore, conservation of these goat breeds is important to protect their diversity (Vallecillo *et al.*, 2004; Manzi *et al.*, 2011), because once it is lost it cannot be replaced (Manzi *et al.*, 2011). Moreover, conservation of genetic diversity provides protection against diseases, feed shortages, selection errors, unforeseen disastrous actions, social and climatic

changes. The main aim of conservation is to keep different genes as pure as possible and to keep special genes of value (Esquivelzeta *et al.*, 2011; Mara *et al.*, 2013).

Phenotypic characterisation is a practice of documenting the physical appearance or characteristics of an animal. The information provided by phenotypic characterisation studies is crucial for planning management and the use of animal genetic resources at local, national, regional and global levels (Food and Agriculture Organization, 2011; Hassen *et al.*, 2012; African Union Interafrican Bureau for Animal Resources, 2014). The phenotypic characterisation tool gathers information on production environment, qualitative, quantitative and adaptive traits (African Union Interafrican Bureau for Animal Resources, 2014). For the conservation and improvement of indigenous animals, phenotypic characterisation should be a first step to be undertaken before the use of their genetic material (Kunene *et al.*, 2007; Yakubu *et al.*, 2010; Hassen *et al.*, 2012).

There are two types of phenotypic characterisation, namely: quantitative and qualitative, which provides information on the identification of unique characteristics within different populations (Yami and Merkel, 2008). Phenotypic qualitative characteristics include the external physical form, shape, colour and appearance of the animals. For examples: coat colour, horn shape and ear length etc (Yami and Merkel, 2008; Hassen *et al.*, 2012; Akpa *et al.*, 2013; Phillips, 2013). These characteristics have less direct significance to the production and service functions of an animal (Food and Agriculture Organization, 2011; Hassen *et al.*, 2012). Phenotypic quantitative characteristics are measures of animal body parts (Pieters *et al.*, 2009; Food and Agriculture Organization, 2011) e.g. body weight and size (Agga *et al.*, 2011; Hassen *et al.*, 2012). These characteristics are more directly associated to production characteristics. For example; body weight and chest girth are directly associated to body size and production characteristics (Agga *et al.*, 2011; Hassen *et al.*, 2012). Phenotypic characteristics have important socio-cultural and economic values to African people. As a result, most farmers have specific respect and choices for specific traits eg goat coat colours and body sizes are more favourable to the farmers (Hassen *et al.*, 2012).

Indigenous goats were regarded as less important animal genetic resource (Pieters *et al.*, 2009; Sahlu *et al.*, 2009). As a result, this has led to their underutilisation and contribution to agriculture (Mekasha, 2007; Manzi *et al.*, 2011). Therefore, an accurate collection of phenotypic information from different South African indigenous goats will assist with future breeding plans, maintenance of unique phenotypic characteristics (Manzi *et al.*, 2011) and will enable an accurate comparison of these goats with other goat breeds (Kunene *et al.*, 2007). The objective of the current study was to characterise and compare South African unimproved indigenous and Tankwa goats' phenotypic characteristics.

## Materials and Methods

The study was approved by ethic committees of the Tshwane University of Technology (REC2012/10/019-2) and Agricultural Research Council (APIEC15/044). The study was conducted at the Agricultural Research Council and Carnarvon Research Station. The Agricultural Research Council is situated on the Highveld (Irene) at an altitude of about 1500 m above sea level. The temperature ranges from 6 to 21°C in winter and 16 to 27.3°C in summer. The rainfall ranges from 0 to 1.4 mm in winter and 84.4 to 106.6 mm in summer (J Matsapola, 5 May 2015).

Carnarvon Research Station is situated in the Karoo area at an altitude of about 1309 m above sea level. The temperature ranges from 1.3 to 20°C in winter and 17.4 to 36°C in summer. The rainfall ranges from 1.9 to 8 mm in winter and 19.2 to 37.8 mm in summer (J Matsapola, 5 May 2015). In the current study, matured South African unimproved indigenous goats (44) from the Agricultural Research Council and Tankwa goats (41) from Carnarvon Research Station were used. The goats at the Agricultural Research Council were kept on natural pasture and supplemented with hay grass during winter season and drinking water was provided ad libitum through metal drinking troughs.

The goats at Carnarvon Research Station on the other hand survived on natural veld with no supplementation during the winter season with access to drinking water. South African unimproved indigenous goats are commonly small sized animals, which stand harsh environments, parasites and diseases, have good maternal ability and are able to survive on poor quality grazing when compared to foreign breeds (Ramsay and Donkin, 2000). Tankwa goats were first discovered in the Tankwa Karoo National Park. It is believed that this goat type may have originated from indigenous goats that were in the area in the 1900s but have since been isolated (Kotze *et al.*, 2014).

Phenotypic quantitative characteristics (body parts measurements) were assessed with the aid of a flexible tape measure and were recorded in centimetres (cm). Individual body weight was determined by using a weighing scale and it was recorded in kilograms (kg). The phenotypic qualitative characteristics were assessed through visual appraisal. Body condition score was assessed based on standard scale which ranges from 1 – 5 (1 = very thin, 2 = thin, 3 = satisfactory, 4 = fat and 5 = obese) (Agga *et al.*, 2011). The age of the males was estimated by counting the number of permanent incisors on the lower jaw of the mouth (Agga *et al.*, 2011).

Phenotypic qualitative data were analysed using a Statistical software for Microsoft Excel (XLSTAT), Version 2013 (New York, USA). For categorical variables, descriptive statistics were determined and data was presented as simple proportions (percentages). Phenotypic quantitative characteristics data were

analysed using the Generalised Linear Model procedures in the Statistical Analysis Software, Version 9.2 (SAS Institute Inc, 1999). LS-means were compared using the LSD test ( $\alpha = 0.05$ ). The statistical model used was:

$$y_{ij} = \mu + \tau_i + e_{ij}$$

Where:

$y_{ij}$  = The observation of the  $j$ -th experimental unit of the  $i$ -th treatment

$\mu$  = The overall mean

$\tau_i$  = The effect of the  $i$ -th treatment or breed

$e_{ij}$  = The residual (error) component

## Results

Table 1 depicted age, general and tail appearance characteristics of South African unimproved indigenous and Tankwa goats. None of the goats had a body condition score of 5 (very fat). South African unimproved indigenous goats did not have very thin (1) and thin (2) body condition scores. However, Tankwa goats had 2 and 18% of very thin (1) and thin (2) body condition scores, respectively. South African unimproved indigenous goats had a higher proportion of satisfactory (3) body condition score (98%) when compared to Tankwa goats (74%). None of the Tankwa goats had ticks under their tails compared to 53% for South African unimproved indigenous goats. Out of 47% South African unimproved indigenous goats that had ticks, 14% had 1 tick, another 14% had 2 ticks, 5% had 3 ticks, 12% had 4 ticks and 2% had 5 ticks.

Table 2 depicted coat cover characteristics of South African unimproved indigenous and Tankwa goats.

South African unimproved indigenous goats had 61% of long fibre, which was higher when compared to Tankwa goats (25%). Tankwa goats had a higher proportion of coat cover with single (21%) and two colours (59%) when compared to South African unimproved indigenous goats (5% single and 39% two colours). However, South African unimproved indigenous goats had a higher proportion of more than two coat colours (56%) when compared to Tankwa goats (20%). White (56%) and brown colours (35%) were more dominant in South African unimproved indigenous goats as the main coat colours, with black colour being the less dominant colour. In Tankwa goats, black colour (49%) was more dominant, followed by brown (26%), red (13%), white (10%) and grey (2%) colour, which were higher when compared to South African unimproved indigenous goats' black, red and grey colour, 9, 0 and 0%, respectively.

Table 3 depicted skin characteristics of South African unimproved indigenous and Tankwa goats. South African unimproved indigenous goats had a higher proportion of small and tight (18%) and big and loose (56%) skin when compared to Tankwa goats small and tight (14%) and big and loose (16%) skin. Moreover, South African unimproved indigenous goats had a higher proportion of thick skin (47%) when compared to Tankwa goats (33%). There was a higher proportion of black (80%), brown (14%) and red (2%) colours in Tankwa goats when compared to South African unimproved indigenous goats' black, brown and red colours, 14, 3 and 0%, respectively. Moreover, a higher proportion of skin part that were not covered with hair was observed in Tankwa goats (100%) than in South African unimproved indigenous goats (31%).

**Table 1:** Age, general and tail appearance characteristics of South African unimproved indigenous and Tankwa goats (%)

Characteristics	Categories	Breeds	
		Unimproved (n = 44)	Tankwa (n = 41)
Age (years)	Age based on number of permanent incisors	1	0
		2	30
		3	58
		4	10
		> 5	2
General appearance	Body condition score	Very thin (1)	0
		Thin (2)	0
		Satisfactory (3)	98
		Fat (4)	2
		Very fat (5)	0
Tail	Appearance	Straight	100
		Skew	0
		None	53
	Ticks	1	14
		2	14
		3	5
		4	12
		5	2

The results are comparable within the same cell on the same row.

**Table 2:** Coat cover characteristics of South African unimproved indigenous and Tankwa goats (%)

Characteristics	Categories	Breeds		
		Unimproved (n = 44)	Tankwa (n = 41)	
Coat cover	Appearance	Coarse	35	14
		Average	63	31
Glossy and shine		2	55	
Fibre form	Straight	100	71	
		Curly	0	25
		Both	0	4
Length	Short	0	22	
		Medium	39	53
		Long	61	25
Colour	Single	5	21	
		Two	39	59
		More	56	20
Main colour	Brown	35	26	
		Black	9	49
		Red	0	13
		White	56	10
		Grey	0	2

The results are comparable within the same cell on the same row.

**Table 3:** Skin characteristics of South African unimproved indigenous and Tankwa goats (%)

Characteristics	Categories	Breeds		
		Unimproved (n = 44)	Tankwa (n = 41)	
Skin	Size	Small and tight	18	14
		Average	26	70
Big and loose		56	16	
Thickness	Thin	16	26	
		Average	37	41
		Thick	47	33
Neck and chest folds	None	95	53	
		Few	5	47
Pigmentation ratio: eye lids	< 25%	46	0	
		26-75%	54	14
		> 75%	0	86
Pigmentation ratio: top line	< 25%	0	0	
		26-75%	88	18
		> 75%	12	82
Pigmentation ratio: bottom line	< 25%	0	2	
		26 - 75%	93	16
		> 75%	7	82
Pigmentation ratio: leg	< 25%	5	2	
		26 - 75%	65	14
		> 75%	30	84
Pigmentation ratio: under tail	< 25%	51	0	
		26-75%	49	16
		> 75%	0	84
Skin colour on hairless part	Black	14	80	
		Brown	3	14
		Red	0	2
		White	14	4
		Fully covered with hair	69	0

The results are comparable within the same cell on the same row.

Table 4 depicted head characteristics of South African unimproved indigenous and Tankwa goats. Both South African unimproved indigenous and Tankwa goats had brown eyes and did not have blue eyes. South African unimproved indigenous goats had a higher proportion of individuals without eye banks (74%) when compared to

Tankwa goats (8%). A higher proportion of untamed males were observed in Tankwa goats (88%) when compared to South African unimproved indigenous goats (2%). The mouth shapes of Tankwa goats were average (100%) which was higher when compared to South African unimproved indigenous goats (91%). On the other hand, Tankwa goats

had a higher proportion of males with undershot (14%) and overshot (2%) lower jaws when compared to South African unimproved indigenous goats undershot (5%) and overshot (0%) lower jaws. South African unimproved indigenous goats had a higher proportion of males with beards (100%) when compared to Tankwa goats (92%). Tankwa goats had a higher proportion of males that had toggles (10%) when compared to South African unimproved indigenous goats (0%).

Table 5 depicted horn and ear characteristics of South African unimproved indigenous and Tankwa goats. All South African unimproved indigenous and Tankwa goats had horns. Tankwa goats had a higher proportion of horns that were dark in colour (33%) when compared to South African unimproved indigenous goats (23%). There was a higher proportion of horns that were undamaged in South African unimproved indigenous goats (98%) when compared to Tankwa goats (47%). Tankwa goats had a higher proportion of long ears (51%) when compared to South African unimproved indigenous goats (9%). Tankwa goats had a higher proportion of soft hanging ears (96%) when compared to South African unimproved indigenous goats (47%).

Table 6 depicted neck, chest, shoulder and torso characteristics of South African unimproved indigenous

and Tankwa goats. Both South African unimproved indigenous and Tankwa goats had the same proportion of well-fleshed necks (21%). Tankwa goats had a higher proportion of shoulders that were ideally attached to the body (63%) when compared to South African unimproved indigenous goats (19%). On the other hand, South African unimproved indigenous goats showed a higher proportion of cylindrical torsos (77%) when compared to Tankwa goats (31%). Table 7 depicted hind quarter characteristics of South African unimproved indigenous and Tankwa goats. Tankwa goats had a higher proportion of sloped (80%), average (14%) and straight (6%) rumps when compared to South African unimproved indigenous goats sloped (77%), average (0%) and straight (0%) rumps. South African unimproved indigenous goats had 23% of roofy rumps, whereas Tankwa goats did not have any roofy rumps.

Table 8 depicted legs characteristics of South African unimproved indigenous and Tankwa goats. Tankwa goats had a higher proportion of thin (8%) and thick (4%) leg diameters when compared to South African unimproved indigenous goats leg diameters (5% thin and 0% thick). South African unimproved indigenous goats had a higher proportion of front legs that were normal (98%) when compared to Tankwa goats (69%).

**Table 4:** Head characteristics of South African unimproved indigenous and Tankwa goats (%)

Characteristics	Categories	Breeds		
		Unimproved (n = 44)	Tankwa (n = 41)	
Head	Nose and forehead shape	Convex	16	67
		Straight	65	31
		Concave	19	2
	Eye colour	Brown	100	100
		Blue	0	0
	Eye width	Narrow	2	2
		Average	94	94
		Wide	4	4
	Eye banks	Absent	74	8
		Average	26	74
		Distinct/separate	0	18
	Look in the eye	Untamed	2	88
		Tamed	98	12
	Nostrils	Small and closed	70	14
Wide and open		30	86	
Shape of mouth	Narrow	7	0	
	Average	91	100	
	Wide	2	0	
Lower jaw	Undershot	5	14	
	Fits well	95	84	
	Overshot	0	2	
Beards	Absent	0	8	
	Present	100	92	
Toggles	Absent	100	90	
	Present	0	10	

The results are comparable within the same cell on the same row.

**Table 5:** Horn and ear characteristics of South African unimproved indigenous and Tankwa goats (%)

			Breeds	
			-----	
Characteristics		Categories	Unimproved (n = 44)	Tankwa (n = 41)
Horns	Type	Horned	100	100
		Polled	0	0
	Growth direction	Backward	67	92
		Sideways	3	8
		Upright	30	0
	Shape	Curved	77	86
		Straight	9	14
		Spiral	14	0
	Colour	Dark	23	33
		Light	77	67
Deviation	Undamaged	98	47	
	Damaged	0	51	
	Right horn damaged	2	2	
Ears	Size	Short	7	4
		Average	84	45
		Long	9	51
	Direction	Soft hanging	47	96
		Stiff side ways	53	4
	Folds	Length wise	79	82
		Breadth wise	21	16

The results are comparable within the same cell on the same row.

**Table 6:** Neck, chest, shoulder and torso characteristics of South African unimproved indigenous and Tankwa goats (%)

			Breeds	
			-----	
Characteristics		Categories	Unimproved (n = 44)	Tankwa (n = 41)
Neck	Length	Short	2	20
		Moderate	93	72
		Long	5	8
	Shape	Thin	2	10
		Fleshed	77	69
Chest	Width	Well fleshed	21	21
		Narrow	16	47
		Average	47	47
	Depth	Wide	37	6
		Shallow	16	53
		Average	44	37
		Deep	40	10
Shoulder and torso	Attachment to body	Loose	5	0
		Average	76	37
		Ideal	19	63
	Withers at the top	Sharp	30	29
		Average	65	57
		Broad	5	14
	Torso	Narrow	5	20
		Cylindrical	77	31
		Broad and Deep	18	49
	Top line	Pinched	12	4
Straight		74	65	
Hollow		14	31	

The results are comparable within the same cell on the same row.

**Table 7:** Hind quarter characteristics of South African unimproved indigenous and Tankwa goats (%)

Characteristics		Categories	Breeds	
			Unimproved (n = 44)	Tankwa (n = 41)
Hind quarters	Rump	Sloped	77	80
		Average	0	14
		Straight	0	6
		Roofy	23	0
	Length	Short	9	14
		Average	86	72
		Long	5	14
	Width	Narrow	5	23
		Average	90	63
		Broad	5	14
	Buttocks and thighs	Short and flat	95	10
		Long and flat	5	74
Well fleshed and round		0	16	

The results are comparable within the same cell on the same row.

**Table 8:** Legs characteristics of South African unimproved indigenous and Tankwa goats (%)

Characteristics		Categories	Breeds	
			Unimproved (n = 44)	Tankwa (n = 41)
Legs	Diameter	Thin	5	8
		Average	95	88
		Thick	0	4
	Front	Normal	98	69
		X legged	2	27
		Bow legged	0	4
	Pasterns	Short	12	21
		Average	88	69
		Long	0	10
	Hocks	Ideal	100	94
		Post legged	0	4
		Cow hocked	0	2
	Hooves size	Small	0	12
		Average	93	86
		Big	7	2
	Hooves condition	Poor	7	40
		Average	25	18
		Good and shiny	68	42
	Hooves length	Well worn	0	69
		Good	98	31
		Too long	2	0
	Heel size	Small	0	8
		Average	93	86
		Big	7	6

The results are comparable within the same cell on the same row.

However, a higher proportion of X (27%) and bow (4%) legs were observed in Tankwa goats than in South African unimproved indigenous goats' X (2%) and bow (0%) legs. South African unimproved indigenous goats had a higher proportion of ideal hocks (100%) with no proportion of post legged (0%) and cow hocked (0%) hocks when compared to Tankwa goats ideal, post legged and cow hocked hocks, 94%, 4% and 2%, respectively. South African unimproved indigenous goats had a higher proportion of hooves condition that were good and shiny (68%) when compared to Tankwa goats (42%).

Table 9 depicted testis characteristics of South African unimproved indigenous and Tankwa goats. South African unimproved indigenous goats had a higher proportion of well-balanced/equal (82%), normal size (95%), good attached (77%) and straight (93%) testis when compared to Tankwa goats (well-balanced/equal, normal size, good attached and straight testis, 70, 59, 76 and 88%, respectively). Tankwa goats had a higher proportion of males without ticks on the testis (100%) when compared to South African unimproved indigenous goats (98%).

**Table 9:** Testis characteristics of South African unimproved indigenous and Tankwa goats (%)

Characteristics	Categories	Breeds		
		Unimproved (n = 44)	Tankwa (n = 41)	
Testis	General appearance	Unequal in size	9	10
		Slightly unequal	9	20
	Size	Well balanced/equal	82	70
		Small	0	25
		Normal	95	59
	Attachment	Large	5	16
		Poor	2	2
		Average	21	22
	Twist	Good	77	76
		< 45°	7	10
		Straight	93	88
	Hair	> 45°	0	2
		Few	2	20
	Ticks	Almost covered	98	80
		None	98	100
		1	0	0
2		0	0	
	3	0	0	
	4	0	0	

The results are comparable within the same cell on the same row.

**Table 10:** South African unimproved indigenous and Tankwa goats' phenotypic quantitative characteristics (LS-mean ± SE)

Characteristics		Breed		
		Unimproved (n = 44)	Tankwa (n = 41)	
Body	Temperature (°C)	40.3 <sup>a</sup> ±0.1	38.5 <sup>b</sup> ±0.1	
	Weight (kg)	35.5 <sup>b</sup> ±2.1	59.8 <sup>a</sup> ±1.9	
Body parts (cm)	Horns length	Left	25.5 <sup>b</sup> ±1.6	35.2 <sup>a</sup> ±1.5
		Right	25.6 <sup>b</sup> ±1.7	36.4 <sup>a</sup> ±1.5
	Heart girth	Circumference	80.9 <sup>b</sup> ±1.3	95.5 <sup>a</sup> ±1.2
		Body	Length	75.4 <sup>b</sup> ±1.7
	Height		69.5 <sup>b</sup> ±0.9	79.1 <sup>a</sup> ±0.9
	Depth		23.9 <sup>b</sup> ±0.6	40.4 <sup>a</sup> ±0.6
	Rump	Width	20.6 <sup>b</sup> ±0.8	45.2 <sup>a</sup> ±0.7
	Hind leg	Width	16.6 <sup>b</sup> ±0.4	22.1 <sup>a</sup> ±0.4
		Length	45.9 <sup>b</sup> ±0.9	80.4 <sup>b</sup> ±0.8
		Length below hock	21.2 <sup>a</sup> ±0.3	24.5 <sup>a</sup> ±0.3
		Length below knee	19.2 <sup>b</sup> ±0.3	20.4 <sup>a</sup> ±0.3
	Hooves	Length	6.7 <sup>b</sup> ±0.1	7.4 <sup>a</sup> ±0.1
		Height	4.1 <sup>a</sup> ±0.1	3.9 <sup>b</sup> ±0.1
	Testis	Circumference	22.7 <sup>b</sup> ±0.4	27.3 <sup>a</sup> ±0.4
	Tail	Length	13.3 <sup>b</sup> ±0.3	17.9 <sup>a</sup> ±0.3

<sup>a,b</sup> Values with different superscripts within the same row differ significantly (p<0.05).

Table 10 depicted South African unimproved indigenous and Tankwa goats' phenotypic quantitative characteristics. South African unimproved indigenous goats had higher (p<0.05) body temperature (40.3±0.1°C) when compared to Tankwa goats (38.5±0.1°C). Tankwa goats were heavier (p<0.05) (59.8±1.9 kg) when compared to South African unimproved indigenous goats (35.5±2.1 kg). All the Tankwa goats body parts measured: length, height, depth; rump width, hind leg width, length, length

below hock and knee, hooves height and length, tail length, heart girth and testicular circumference were longer (p<0.05) when compared to South African unimproved indigenous goats.

## Discussion

In the current study, both South African unimproved indigenous and Tankwa goats had satisfactory body



condition score (3); with South African unimproved indigenous goats having a highest proportion (98%) when compared to Tankwa goats (74%). This might be because South African unimproved indigenous goats were supplemented with hay grass during the winter season (Nsoso *et al.*, 2004) and the water was provided ad libitum. However, Tankwa goats did not receive any supplements and they were walking longer distances to get access to water. For South African unimproved indigenous goats, there were no males that had very thin and thin body condition score. However, Tankwa goats had 2% very thin and 18% thin body condition score. This might be due to unavailability of some nutrients (Nsoso *et al.*, 2004), as the goats were on extensive farming system. According to Askar *et al.* (2015) nutrients supplementation enhances body condition score of an animal. If the nutrients are unbalanced, the consequences are weight loss, metabolic dysfunction and hormonal imbalance amongst others (Rosales-Nieto *et al.*, 2011).

Although in Tankwa goats the body condition was generally poor compared to South African unimproved indigenous goats, the proportion of fatter goats was higher than in South African unimproved indigenous goats. This seems to be due to differences in management. Bucks with body condition score of 4 and above are culled at Agricultural Research Council because they were found to be less productive, lazy to mount and if they mount, they will mate few does (Penn State College of Agricultural Sciences, 2015; Pezzanite *et al.*, 2015). However, at Carnarvon Research Station there was no culling for undesirable body condition. When the findings of the current study were compared with a previous study in Mexico, South African indigenous goats' body condition was much better when compared with Black Bedouin and Black Bedouin X Damascus goat males. The difference between the current and previous study might be due to different feeds that the goats had access to. In the current study, goats were exposed more to natural grazing, whereas, in Mellado *et al.* (2012) study the goats were fed with a commercial diet.

All the experimental goats used in this study were mature and optimal for breeding, as they were above 6 months of age (Pezzanite *et al.*, 2015). In South African unimproved indigenous goats, the highest proportion was 3 years old, followed by 2 years old males and 4 years old males and the lowest proportion was 5 years old males and above. The reason why there was a low proportion of older males at the Agricultural Research Council is because of the culling process which is practiced (older goats are sold) (Nsoso *et al.*, 2004). However, there was no culling of goats practiced at Carnarvon Research Station. The age of mature males at the Agricultural Research Council aligns well with Pezzanite *et al.* (2015), who indicated that the optimal

breeding age of male goats ranges from 6 months to 4 years. Moreover, the age range of the goats at Agricultural Research Council seems to be a standard range that the intensive farmers or research institutes are keeping (Kridli *et al.*, 2007).

South African unimproved indigenous goats had few ticks under their tails and on the testis. This was indicated to have a good relationship with the skin thickness. It has been documented that, ticks bite more thick and loose skin than thin and tight skin (de Castro *et al.*, 1991; Botha, 2007). In the current study, goats that had more tick bites had thicker and loose skin. This might be due to hair length as South African unimproved indigenous goats had long hair that might serve as ticks' carrier. Short hair was documented to develop much less static electricity when stroked and affords little protection against ticks, which do not like to be exposed to the sun. As a result, few ticks will attach themselves on the thick skin (Botha, 2007). In general, both South African unimproved indigenous and Tankwa goats were tolerant to ticks (Pieters, 2007).

Glossy and shiny hair was observed more in Tankwa goats than in South African unimproved indigenous goats. According to Akpa *et al.* (2013), hair type and coat pigment do not have an influence on body weight, conformation or semen parameters but indicate the productive adaptability of an animal. Glossy hair was reported to grow cashmere in cold winters (Snyman, 2014) and animals with glossy hair coat are less adaptable to hot climates, which makes them to be less productive when it is hot (Akpa *et al.*, 2013). South African unimproved indigenous goats had straight fibre only. However, Tankwa goats had straight fibre (71%), curly (25%) and a combination of curly and straight fibre (4%). These results are in agreement with Kayamadi (2007) who indicated that South African indigenous goats vary in coat type.

Hair type is an indication of an animals' physiological status, especially the functioning of the endocrine system and effectiveness of energy metabolism (Akpa *et al.*, 2013). South African unimproved indigenous goats showed a high proportion of males that had long fibre when compared to Tankwa goats. The reason for this is not clear but it could be due to temperature variation in the two areas (Botha, 2007). Short hair was reported to have an advantage over long hair as it provides a medium for convectional heat loss from the animal surface and on the other hand, long hair serves as a carrier of external parasites (Botha, 2007; Akpa *et al.*, 2013).

Most of the Tankwa goats had single or two colours as their main colours when compared to South African unimproved indigenous goats that had a high proportion of more than two colours. In Tankwa goats, black colour was more dominant followed by brown, red, white and

grey, respectively. However, in South African unimproved indigenous goats, white colour was the most dominant colour followed by brown and black. Brown and white colours were more dominant in South African unimproved indigenous goats than in Tankwa goats. On the other hand, black, red and grey colours were dominant in Tankwa goats than in South African unimproved indigenous goats.

According to Hassen *et al.* (2012), coat colour has socio-cultural and economic values to African people. For example: black goats are less preferred in the Amhara region (Ethiopia) and Zululand region (South Africa) because they are believed to bring bad luck in the family. As a result, they have a direct effect on goat marketing value (Hassen *et al.*, 2012; Phillips, 2013). The favourite colours in those regions were reported to be white, grey, brown and red (Phillips, 2013). In South Africa at Venda area, black goats are more preferred for rituals (Mashau, 2007) and are also believed to have good adaptation to cold weather as absorption of solar radiation by black pigment is faster than goats with other coat colours (Hassen *et al.*, 2012; Okourwa, 2015).

The variation in colours observed in the current study was not surprising, as it has been documented that South African indigenous goats have a variety of colours (Kayamadi, 2007; Morrison, 2007; Snyman, 2014). This shows that South African indigenous goats in different areas of South Africa share some common characteristics. The colour domination and variation of these South African unimproved indigenous and Tankwa goats in the current study was suggested to be due to the genetic composition and breeding lines that are currently used and available at the Agricultural Research Council and Carnarvon Research Station. The multi and solid coloured patterns observed have been reported to help the goats to be difficult targets for predators, due to their different colorations (Morrison, 2007).

Most of the Tankwa goats had a convex forehead whereas South African unimproved indigenous goats had straight and concave foreheads. This is in agreement with Morrison (2007), who indicated that forehead shape tends to be flat or slightly concave in South African unimproved indigenous goats. Both South African unimproved indigenous and Tankwa goats had brown, narrow, average and wide eyes. Based on appearance of their eyes, South African unimproved indigenous goats were tamer than Tankwa goats. This might be due to the fact that South African unimproved indigenous goats are used to people during the trainings that are given to different stakeholders visiting the institute. Moreover, this might be due to handling (Kruger, 2014) when semen is collected, routine check of their well-being, counted and moved from one camp to the other etc. However, Tankwa goats are managed with little human interference. Taming of animals is

beneficial for experimental purposes, as it changes animals' behaviour and physiology. However according to Mellor (2004), in a natural environment it is a disadvantage since it changes animals' responses to stimuli such as stock theft and predation.

All the South African unimproved indigenous goats had beards with no toggles. On the other hand, 92% of Tankwa goats had beards and 90% of them did not have toggles. In terms of the toggles, the results of current study are in line with the literature as it has been documented that toggles are dominantly found in dairy, pygmy and Spanish goats (Hassen *et al.*, 2012). The presence of beards in both South African unimproved indigenous and Tankwa goats was expected, as it has been indicated that they are more dominant in males than in females, which flows into the longer hair of their neck (Snyman, 2014).

All the South African unimproved indigenous and Tankwa goats had horns and most of their horns were facing backwards. The presence of horns in animals is considered to be good for blood circulation through the cavernous sinus, as a control mechanism for thermal homeostasis (Food and Agriculture Organization, 2011; Hassen *et al.*, 2012). It has also been anticipated that there is a good relationship between horns and male fertility in goats (Hassen *et al.*, 2012). However, the current study did not confirm that. Horns serve as an excellent herding instinct that help animals to protect themselves from predators (Morrison, 2007). In the current study, different horns' shapes were observed. South African unimproved indigenous goats had upright, curved and spiral horns, whereas Tankwa goats had curved ones only. This is in agreement with the literature, as it has been documented that South African indigenous goats' horns shape vary (Kayamadi, 2007; Morrison, 2007) and are more inclined to curve backwards (Morrison, 2007).

Tankwa goats' horns were more damaged when compared to those of South African unimproved indigenous. This may be due to excessive use of their horns for self-defence against predators as they are not housed. It might also be due to environmental effects as Tankwa goats are currently staying at a rocky and mountainous environment. However, South African unimproved indigenous goats are staying in a plain and even environment without rocks and mountains (semi-intensive) (Wiedemar *et al.*, 2014). Tankwa goats' ears were longer when compared to South African unimproved indigenous goats that had short and average ears. According to Food and Agriculture Organization (2011), goats that have long ears are well adapted to dry and hot climatic conditions. This makes sense because the environmental temperatures at Carnarvon Research Station are higher when compared to the environmental temperatures at the Agricultural Research Council (J

Matsapola, 5 May 2015). In terms of the ear type, Tankwa goats had more soft hanging ears with lengthwise folds when compared to South African unimproved indigenous goats. On the other hand, South African unimproved indigenous goats' had stiff and sideways facing ears with breadthwise folds. The results of the current study are in agreement with Kayamadi (2007) who indicated that South Africa indigenous goats' ears comes in different shapes and forms.

South African unimproved indigenous and Tankwa goats used in this study showed some close similarities with regards to withers, top lines, average chest width, necks, rump slope and length. Their fleshed necks might be due to the fact that their general body condition score was satisfactory. Tankwa goats' hooves condition were poor when compared to South African unimproved indigenous goats. However, this was not surprising as the environmental conditions where Tankwa goats were located was harsh when compared to the environmental conditions where the South African unimproved indigenous goats were kept. There was a high proportion of well-balanced testicles in South African unimproved indigenous and Tankwa goats. This means that their testicles were firm, movable within the scrotum and their sizes were good (Morrison, 2007; Pezzanite *et al.*, 2015). However, Tankwa goats had a higher proportion of unequal, slight unequal, small, average and large testis when compared to South African unimproved indigenous goats. This was not surprising as at the Agricultural Research Council, breeding soundness evaluation is done on males, meaning that most of the males kept are superior or are good for breeding purposes (Akpa *et al.*, 2013; Pezzanite *et al.*, 2015).

South African unimproved indigenous goats' body temperature (40.3°C) was higher when compared to Tankwa goats (38.5°C). According to Robertshaw (2004), this is above the normal body temperature (38.5-39.7°C) recommended for goats. This might be due to the fact that long hair makes heat loss from the animal surface a challenge (Akpa *et al.*, 2013). The testicular circumference obtained in the current study was higher when compared to the testicular circumference of 17.3±0.26 cm recorded in Red Sokoto males (Akpa *et al.*, 2013). Such difference might be due to breed and age differences (Gebre, 2007), as in Red Sokoto males, it ranged from 9-24 months (Akpa *et al.*, 2013). However, in the current study the males' age ranged from 1 year to > 5 years. The testicular circumference obtained in the current study was still within the acceptable range of 17 and 25 cm in young and older males, respectively, which is recommended to be used for breeding in goats (Kridli *et al.*, 2005; Ajani *et al.*, 2015).

All the Tankwa goats body parts measured: length, height, depth; rump width, hind leg width, length, length

below hock and knee, hooves height and length, tail length, heart girth and testicular circumference were longer when compared to South African unimproved indigenous goats. In all the body parts measured, there was an increase as the goats' age increase. This is expected since animal size was reported to increase with age (Akpa *et al.*, 2013). Tankwa goats were also heavier than the South African unimproved indigenous goats. This might be due breed and environment differences, variety of grass and shrub that they had access to at Carnarvon Research Station (nutrition) (Perez and Mateos, 1996; Gebre, 2007).

Generally, heart girth circumference, body weight, height, length and depth of the males in the current study were higher when compared to the findings of Keith *et al.* (2009); Pieters *et al.* (2009); Akpa *et al.* (2013). The differences might be due to age of the males, as in the current study males age ranged from 1 year to > 5 years, whereas in the previous studies it ranged from 8 to 9 months (Keith *et al.*, 2009), average of 12 months (Pieters *et al.*, 2009) and 9 months to 2 years (Akpa *et al.*, 2013). It might also be due to breed differences, as in the previous studies; Boer (Keith *et al.*, 2009), Boer, Kalahari red, Savana (Pieters *et al.*, 2009) and Red Sokoto goats (Akpa *et al.*, 2013) were used. Both South African unimproved indigenous and Tankwa goats used in the current study were classified as large-sized animals as their body heights were above > 65 cm (Hassen *et al.*, 2012). The body length and height obtained in the current study showed some similarities with Webb *et al.* (1998) who obtained a minimum body length and height of 56 and 51 cm, respectively.

The average body height (74.3±0.9 cm), length (93.6±1.7 cm), rump width (32.9±0.8 cm) and heart girth circumference (88.2±1.3 cm) obtained in the current study were higher when compared to Ethiopian indigenous goats that are located on the same subtropical region: body height (67.6±0.29 cm), length (63.2±0.29 cm), rump width (13.6±0.08 cm) and heart girth circumference (72.4±0.32 cm) (Hassen *et al.*, 2012). Moreover, South African unimproved indigenous goats' body depth was higher when compared to other South African indigenous goats such as Boer, Kalahari and Savannah that had 26.4, 27.1 and 24.9 cm, respectively (However, Tankwa goats' body depth was lower when compared to the other South African indigenous goats in the previous study (Pieter *et al.*, 2009).

Body weights reported in the current study were higher when compared to Red Sokoto males' body weight (15.02±0.46 kg). The difference might be due to age differences, as in the current study males were older when compared to Red Sokoto males. The results in the current study align well with the literature as it has been documented that body weight is influenced by age,

meaning that older goats are heavier than younger goats. The skeletal dimensions such as heart girth and body height are good indicators of body weight and condition score (Akpa *et al.*, 2013). Both South African unimproved indigenous and Tankwa goats used in this study were lighter when compared to Black Bedouin and Black Bedouin X Damascus males ( $63.2 \pm 5.0$  and  $60.4 \pm 7.1$  kg, respectively) used in the previous study (Mellado *et al.*, 2012). That might be due to breed differences and feeding regime as in Mellado *et al.* (2012) study a commercial diet was used to feed the experimental animals (Kridli *et al.*, 2007), whereas in the current study they were grazing on natural pasture. However, some of the body measurements of South African unimproved indigenous and Tankwa goats' evaluated in the current study fall within the literature estimates from tropical and subtropical breeds (Nsoso *et al.*, 2004).

South African unimproved indigenous and Tankwa goats' length below hock in the current study was lower when compared to other South African indigenous goats used in the previous study. This shows that there are breed differences on phenotypic characteristics. Moreover, South African unimproved indigenous goats' tail length was similar with other South African unimproved indigenous goats' tail length reported in the previous studies. However, Tankwa goats' tail length was shorter when compared to other South African indigenous goat tails length observed in a previous study (Pieters *et al.*, 2009). Although in the current study it was not investigated, it was documented that body measurements are the indicators of potential reproductive performance (Hassen *et al.*, 2012) such as growth status, development of sperm cells and semen production (Agga *et al.*, 2011).

## Conclusion

The qualitative characteristics were comparable between South African unimproved indigenous and Tankwa goats. However, quantitative characteristics of Tankwa goats were good, with the exception of body temperature. Most of the differences observed between Tankwa and South African unimproved indigenous goats seem to be due to genetics, environmental factors (i.e. rainfall and temperature) and management factors (i.e. health practices and feeding systems). This is the first study to report on the phenotypic characteristics in Tankwa goats. The information obtained in this study will contribute in decision-making policy for the conservation, breeding and improvement programmes of indigenous goats' genetic resources.

## Acknowledgement

The technical support from the Agricultural Research Council, Tshwane University of Technology, National

Zoological Garden, National Research Foundation, Northern Cape Department of Agriculture, Land Reform and Rural Development; and University of the Western Cape is well appreciated.

## Funding Information

The financial support from Department of Agriculture, Forestry and Fisheries and Council for Scientific and Industrial Research - Southern African Science Service Centre for Climate Change and Adaptive Land Management (TASK 229) is well appreciated.

## Author's Contributions

**Fhulufhelo Vincent Ramukhithi:** Contributed on the original ideas of the manuscript, data collection, analysis and interpretation; and manuscript write up.

**Khoboso Christina Lehloenya:** Contributed on the original ideas of the manuscript and manuscript preparation.

**Antoinette Kotze:** Contributed on the original ideas of the manuscript, data collection and manuscript preparation.

**Khathutshelo Agree Nephawe:** Contributed on the original ideas of the manuscript and manuscript preparation.

**Tshimangadzo Lucky Nedambale:** Contributed on the original ideas of the manuscript and manuscript preparation.

**Mokgadi Magdelin Seshoka:** Contributed to data collection and interpretation.

**Thinus Jonker:** Contributed on the original ideas of the manuscript and data collection.

**Tlou Caswell Chokoe:** Gave valuable scientific inputs and data collection.

## Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and no ethical issues involved.

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