Vol. 12(2), pp. 64-75, April-June 2021
DOI: 10.5897/IJLP2020.0743
Article Number: D153E7F66682
ISSN: 2141-2448

http://www.academicjournals.org/IJLP

ACADEMIC JOURNALS
expand your knowledge

International Journal of Livestock Production

Full Length Research Paper

Goat farmers' production objectives and trait preferences in the North West province of South Africa: An approach to identify selection criteria for community-based breeding programs

Thobile Fortunate Mtshali[1], Olivia Ntanganedzeni Mapholi[2], Keabetswe Tebogo Ncube[3], Edgar Farai Dzomba[3], Tlou C. Matelele[5], T. C. Chokoe[5], T. D. Mphahlele[5], Farai Catherina Muchadeyi[4] and Khanyisile Hadebe[4]*

[1]Agricultural Research Council, Vegetable and Ornamental Plants, Private Bag X293 Pretoria, 0001, South Africa.
[2]College of Agriculture & Environmental Sciences, School of Agriculture and Life Sciences, University of South Africa, Florida Campus, Private Bag X6, Florida, 1710, South Africa.
[3]Discipline of Genetics, School of Life Sciences, University of KwaZulu-Natal, Private Bag X01, Scottsville, 3209, South Africa.
[4]Agricultural Research Council, Biotechnology Platform, Private Bag X5, Onderstepoort, 0110, South Africa.
[5]Department of Agriculture, Land Reform and Rural Development, Genetic Resources, Private Bag X973, Pretoria, 0001, South Africa.

Received 5 October, 2020; Accepted 30 December, 2020

Breeding practices and trait preferences are key to defining sound breeding objectives and designing genetic improvement programs at community level. The current study identifies these factors for village goats within a pilot community-based breeding program in Pella village, North West province, South Africa. Thirty-five farmers were interviewed using semi-structured questionnaire survey to characterize goat farmers' production system. Breeding objectives were identified in 26 households using own flock ranking experiment and the body weight (kg) and linear measurements (cm) were collected for 10 best does and bucks. Majority of famers were males (83%) and literate (85.7%). Fifteen (43%) farmers owned a buck, and those that did not, relied on communal bucks. Average flock per household was 21±19. Farmer selling price for does was R1588.68±313.17 and bucks were sold for R1663.89±861.91. Body size traits were ranked high for both bucks (0.22) and does (0.10), followed by growth rate of 0.10 does and 0.08 for bucks. Average live body weight for all goats was 38±12 kg. Except for rump length, all linear body measurements studied were significantly correlated with body weight (*p*<0.0001) with chest girth having the highest correlation coefficient (r = 0.70). Breeding objectives and trait preferences established in this study provide primary data required to design a sustainable breeding program and must be incorporated into selection decisions to address farmer preferences.

Key words: Breeding objectives, selection criteria, ranking, goat improvement, trait preference.

INTRODUCTION

Indigenous goats are important livestock species in smallholder farmers in rural areas of South Africa and other developing countries due to their role in home consumption, socio-cultural activity and financial security (Dube et al., 2015; Mahlobo, 2016; Mdladla et al., 2016; Sunder et al., 2018). Smallholder farmers prefer keeping goats than any other livestock species, as they require low input, low feed intake due to their small body frame and have a high metabolism rate (Silanikove and Koluman, 2015). There are most prevalent known communal goat ecotypes described in South Africa (Visser and Marle-Köster, 2018). These ecotype populations vary in body size, geographic distribution and in phenotypic characteristics (Morrison, 2007). Although these ecotypes are phenotypically diverse, they share similar genetic components (Mdladla et al., 2016).

Communal goat production herd in South Africa as in other developing countries are characterised by limited number of animals per unit area and low productivity per animal (Mahlobo, 2016). Mating is uncontrolled, undefined and random (Sebei et al., 2004). Lack of defined breeding strategies, genetic dilution and loss of adaptable genetic resources put indigenous goats at high risk of inbreeding depression which can lead to reduced fitness of a population with many homozygous genotypes (even if they are not deleterious or recessive) (Kosgey, 2006; Gizaw, 2010). As in most village goat production system, goat production in Pella village, North West is limited by forage scarcity, diseases, and indiscriminate communal breeding (Mdladla et al., 2016). There is a need to develop strategies suitable to improve goats under the hands of communal farmers.

Previously in South Africa, livestock improvement strategies largely focused on introducing high performing Boer, Kalahari Red, Savanna and exotic dairy breeds such as Saanen into village-based populations (Marshall et al., 2019). These efforts have not been successful due to incompatibility of these genotypes and their crosses to the low input production system and climatic conditions (Bhuiyan et al., 2017). Additionally, farmers breeding objectives were not incorporated in the improvement strategy thus creating a need to design proper breeding improvement programs (that is, community based-breeding program (CBBP)) in order to enhance the utilization and conservation of genetic diversity of local goat populations.

Smallholder farmers have limited access to improved breeding stock or artificial insemination amenities (Getachew et al., 2018) and often rely on sharing of bucks through communal grazing (Gwaze et al., 2009). CBBP is a unique village-based breeding program that is planned, designed, and implemented by smallholder farmers to genetically improve their flocks (Gizaw et al., 2013). The use of the community's own genetic resources to produce males instead of the regular use of externally produced males strongly support that the CBBP is best suitable for village livestock farming (Getachew et al., 2018). CBBPs have been successful in indigenous sheep and chickens of Ethiopia (Mirkena, 2010; Dana et al., 2011) and in goats in Liberia (Karnuah et al., 2018). Various countries such as Malawi have since joined to implement it in rural goats of Mzimba and Nsanje districts of Malawi (Nandolo et al., 2016). Feed the Future - USDA Livestock Improvement Project and the African Goat Improvement Network (AGIN) have also adopted the program working toward improving flock genetic quality, animal health and productivity, and income from sales in African countries while ensuring the suitable management, utilization and conservation of the local goat genetic resource (Greene and Silverstein, 2012; Weaver, 2013; https://www.usaid.gov/what-we-do/agriculture-and-food-security/increasing-food-security-through-feed-future). South Africa is also adopting the program and is currently in the process of record keeping of farming activities and selecting bucks that will be used for a breeding program. Pella is a pilot study therefore understanding farmer's breeding objectives and trait preference are part of essential elements in developing a successful community based-breeding program.

Other African countries that are in different stages of CBBP implementation used a bottom up approach method by involving farmers in the design CBBP, and taking into account their production system, production challenges and breeding objectives (Gizaw et al., 2013; Abraham et al., 2014; Ahmed et al., 2015; Lorato et al., 2015; Nandolo et al., 2016; Karnuah et al., 2018). In these countries, body conformation, growth rate, adaptation, twining, coat colour, litter size and age at first kidding were among the highly ranked selection criteria for breeding does. Growth rate, higher mature weights, appearance, survival traits and coat colour type formed were the criterion used for breeding buck selection. The success of CBBP in Ethiopian sheep, has been linked the incorporation of the production system, production challenges, and breeding objectives (Kosgey et al., 2006). Smallholder farmers face numerous constraints including the absence of a systematic community breeding programs at village level despite the communal use of grazing pastures (Gebreyesus et al., 2013). The production system characteristics, production challenges and the genetic evaluation has been studied in Pella village, North West province, where high genetic diversity and low inbreeding levels were observed (Mdladla et al., 2016). There are still gaps to utilisation of the diversity and unique adaptive traits of village goats by and unique adaptive traits of village goats by implementing

*Corresponding author. E-mail: MdladlaK@arc.agric.za. Tel: 012 529 9353.

improvement strategies for communal farmers in this area. The Agricultural Research Council and University of KwaZulu-Natal has initiated CBBPs in this community, therefore, the definition of farmers' breeding objectives and trait preference is important. Thus, the aim of this study was to characterize goat production system, establish breeding practices, and trait preferences of goat farmers in Pella village, North West province.

MATERIALS AND METHODS

Ethics

Ethical clearance was obtained from the University of South Africa College of Agriculture and Environmental Sciences, Ethics Committee (2019/CAES/058).

Description of study site

The study was carried out in Pella village, Moses Kotane local municipality in the North West province of South Africa. Pella occupies 14.77 km^2 with a population size of 9223 (Census, 2011). This area is situated at latitude 25° 09´ 60.00´´S and longitude 26° 49´ 59.99´´. Summer months (August to March) have rain associated with thunderstorms with temperatures ranging between 22 and 34°C and winter months (May to July) have dry sunny days with cold nights. The province has an above average rainfall of 300 to 700 mm annually (www.sa-venues.com; Accessed 29 August 2019). Moses Kotane municipality has 2070 households owning 1 to 10 goats, 788 households owning 11 to 100 goats (DRDP, 2016).

Sampling

A total of 35 goat farmers participating in the community-based breeding program in Pella village, North West province of South Africa were interviewed using a semi-structured questionnaire and informal focus group discussions. In total, there are 711 goats within the CBBP. Ten farmers kept their goats in another subsection of the Pella village called Goedgedagt due to space and pasture availability, while 25 kept their animals in their households. Prior to the interview, permission to conduct the study was obtained with the Bakwena ba Morare ba Modimosana tribal authority.

Data collection

The questionnaire was adapted from Abegaz et al. (2014) and translated to Setswana, a local language spoken by the farmers. The questionnaire was designed to obtain information on the general household demographics, the animal reproductive performance, mating, breeding management and other management activities such as feeding, housing, access to market, animal health and production and constraints. Data on mortality rate that happened in the flock was captured.

Participatory definition of selection criteria/breeding objectives was administered through a questionnaire survey. The household heads or herdsman were asked to rank from a list of predetermined breeding objectives, the most important traits and reasons considered when selecting breeding animals (bucks and does). Traits ranked included phenotypic traits (body size, hair type, coat colour, coat colour pattern), conformation traits (ears, horns, teats, wattle, beard), life history (temperament, growth rate, disease resistance/survival), reproduction for does (birthing ease, milk production, mothering ability, longevity, twinning rate, kid sex ratio, kid survival, kidding interval), and reproduction for bucks (early sexual maturity).

Breeding objectives were identified using participatory approach (own flock ranking experiment). Each farmer was visited in the morning before animals were released for feeding and was asked to select and rank a maximum of 10 does and 10 bucks (depending on the flock size) from the most preferred (1) to least preferred (10). Data on the age, body measurements (cm); CG = Chest girth; RW = Rump width; RL = Rump length; BW = Body weight; RH = Rump height; SC = Scrotum circumference for bucks; CB = Canon bone; WH = Withers height; SH = Sternum height; BL = Body length), body condition score, disease incidence and the price they would sell each ranked goat were captured. The age of the animal was determined by permanent incisors dentition; body weight was taken using a weighing scale.

Statistical analysis

The SPSS version 25 (SPSS Inc., Chicago, Illinois, USA, 2015) was employed to generate frequencies on farmer's profile, participation of the different gender groups and management practices for goat in the village. Percentage and frequency were applied to compare the proportion of flock size and composition, breeding strategies, source of bucks, breeding does, breeding buck and castrate to recognize flock characteristics.

Indexes were calculated for all ranking data according to a formula: Index = sum of ranks (3 for rank 1 + 2 for rank 2 + 1 for rank 3) given for an individual reason (attribute) divided by the sum of ranks (3 for rank 1 + 2 for rank 2 + 1 for rank 3) for overall reasons. For the matrix ranking activity, a rank score was calculated for each top three ranked grazing species based on the proportion of ranks each received: 1 for highest ranked, 3 for lowest ranked species according to each criterion. It was calculated as follows: Index = sum of (3 × frequency of R1 + 2 × frequency of R2 + 1 × frequency of R3) for selection criterion divided by sum of (3 × frequency of R1 + 2 × frequency of R2 + 1 × frequency of R3) for all selection criteria.

Body measurement data were analysed using descriptive statistics and GLM procedures of SAS version 9.4 (SAS, 2014) to evaluate the significance of sources of variation affecting measurements of each animal. Sex, age and interaction between sex and age were fitted. N values were different because some measurements had missing values (they were not measured in the field), total number of animals selected was 210, and statistical programs excluded missing values. Correlation coefficients between body weight and other body measurements were calculated using Pearson correlation coefficients.

RESULTS

General household characteristics

Percentage of respondents' gender and age group is as shown in Figure 1. Farmers who received formal education accounted for 77.1%; 28.5% achieved primary level (grade 1-7) while 45.7% achieved high school and 2.9% achieved tertiary education. The average number of people per household was 5±3. Farmers depended on agriculture as the source of income accounted for 60.0% of the respondents, 25.7% depended on trade. Those

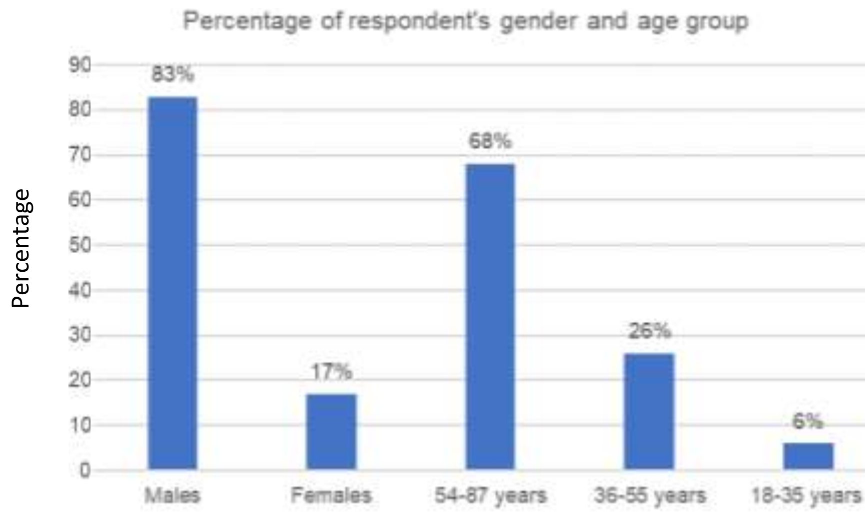

Figure 1. General household information: gender (male and female) and age group (years) of farmers in the community-based breeding program in Pella village, North West province, South Africa

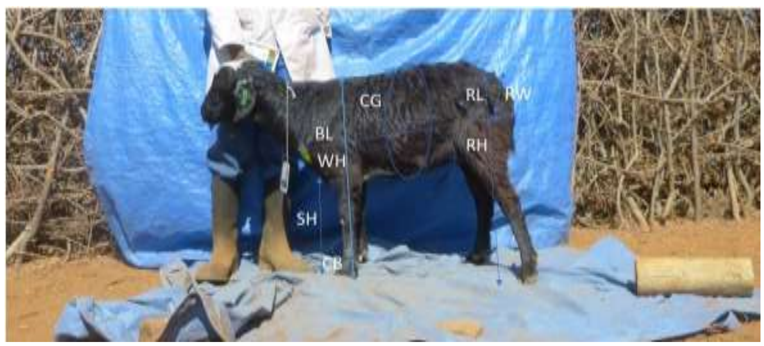

Figure 2. Morphological measurements taken from goats in the study. The body measurements included chest girth (CG), rump width (RW), rump length (RL), rump height (RH), canon bone (CB), withers height (WH), sternum height (SH) and body length (BL).

that depended on agriculture and salary, agriculture and trade and salary alone accounted for 2.9% on each category while 5.7% depended on their pension money for source of income. Farming practice in Pella included keeping livestock only (74.3%), followed by mixed crop and livestock farming (14.3%) and vegetable farming only (11.4%). The number of goats per farm ranged from 1 to 88 while the mean flock size per household was 21±19 heads with a maximum of 13 does and 5 bucks. There was on average 15 female kids and 2 males per household. All respondents kept goats for income, home consumption and for investment.

Reproductive performance

About 71.4% (n = 25) and 62.9% (n = 22) indicated that they predetermined the age at first mating for does and bucks, respectively. Both does and bucks started mating as they turned one year, and it took an average of one year for a doe to have its first kid. The most frequent types of birth were twins (51.5% respondents), followed by singles (34.3%) and both single and twins 14.3%. The average reproductive age of the does was 2 years, with each doe giving 6 or more kids in a lifetime. Kidding was most frequent in May, June and July.

Mating and breeding management

Out of 35 farmers, 15 owned bucks. Farmers without bucks used bucks from their neighbors (n = 19) and one farmer bought his breeding bucks. Six farmers had more than one buck. Out of 35, 29 farmers had no management strategy for breeding buck. One buck serviced the same flock for 3 to 5 years. It was observed that mating within the households was done by mixing bucks with does throughout the year (88%) whilst only 12% of the farmers introduced a buck to does during the mating season. Eighteen farmers out of 32 practiced controlled mating by castrating unwanted bucks and introducing selected bucks to does at fixed time while 14 did not practice controlled mating. Castration of bucks was done between 1 and 3 months of birth. About 65 and 76% of farmers did not practice culling of does and bucks, respectively. Farmers got replacement bucks from young kids from their flock (24), from bucks bought from auctions (5) while others borrowed bucks from neighbors (6). Of the 35 farmers interviewed, 35 selected the best females and 28 selected the best males to be the parents for their next generation. Selection criteria for females was based on body size or appearance, kidding frequency and twining ability, while for males the criteria was size/appearance, growth, behavior and age at maturity animals. Farmers allowed bucks to mate with closely related does.

Market

About 50% of the farmers indicated that they sold their goats at the age of one year, while 40.6% sold them between 3 and 6 years. A percentage of 9.4 farmers sold their goats at any age. The average body weight of highly ranked does was 37.7±12.1 kg whilst that of bucks was 40.4±11.1 kg. Does were sold for R1588.7±313.2 at 38 months whilst bucks were sold at R1663.9±861.9 at 28 months. The price for selling goats was independent of the age (p = 0.2527), sex (p = 0.0642), including the interaction between these two variables (p = 0.0695). Correlation coefficient (r) between body weight and price of goat was 0.40 (p = 0.0001).

Management

Grazing pasture was the major source of goat feed in all seasons. About 57% of farmers did not provide feed concentrate for their goats and indicated expense as a limiting factor. Forty three percent provided bran and homemade concentrate for their goats during the dry season. In the current study, farmers kept their goats in shelters made with branches of thorn trees (77%), while the rest of the farmers made fences with wires and wooden poles (23%). Kids were housed together with adults; moreover, about 66% of farmers housed goats together with other livestock species such as sheep.

Health

Gall disease known as *Anaplasmosis* was reported as the most common disease (42.9%) followed by foot rot (14.3%), sores in genital area and mouth 5.8% and fever 2.9%. About 34.1% (n = 12) of farmers did not know the major goat diseases in their area. According to farmers responses and knowledge, these diseases (gall, foot rot, fever and sores in genital area and mouth), were not contagious and did not affect a specific age group. Farmers treated gall disease in their goats by using vinegar, aloe and terramycin. They did not have any method they use to treat foot rot. Out of 35, 32 people said that they got vaccination service from the local agriculture office, nonprofit organization, chemist and private veterinary centers. Few farmers vaccinated their animals in the autumn, but most of the farmers were not sure when their goats were vaccinated.

Farmers reported that about 126 goats died during the end of 2017 and beginning of 2018. There were 48 young does (age <1 year), 4 young bucks (<1 year), 45 does (>1 year), 9 bucks (>1 year), 8 kids (< 6months) and 14 castrates that have died during this period of time. Half of these goats (52.4%), died from diseases, 19% from predators, 14.3% from unknown causes, 4.8% due to rain while 9.5% were slaughtered for home consumption.

Production and constraints

Out of 35 farmers, 29 slaughtered their goats for home consumption, while others for cultural activities (6). Some farmers slaughtered goats up to 4 times a year. Farmers slaughtered males between the ages of 1-3 years. About 62% of farmers used goat milk for consumption and some (38%) processed it into milk products such as sour milk. Farmers who milked their goats did so only once a day. Farmers did not keep records of weaning weights and did not restrict kids from suckling on their mothers. Famers experienced production constraints that included management skills, diseases, drought, predators and lack of extension services.

Selection criteria for does

In selecting breeding doe, body size (0.10) was ranked first followed by growth rate (0.08), disease resistance (0.08), milk production (0.07) and mothering ability (0.07). Kid sex ratio (0.01) was ranked the least preferred trait as shown in Table 1. Selected does had mean body weight of 37.7 kg±12.1.

Selection criteria for breeding bucks

Body size (0.22), growth rate (0.15) and disease resistance (0.15) were the highly ranked criteria for selecting breeding buck. Traits such as ears (0.07), horns (0.07) and early maturity (0.07) were among preferred selection criteria. Teats were least preferred as illustrated in Table 2. Highly ranked bucks selected had a mean body weight of 40.4±11.1 kg.

Table 1. Selection criteria of farmers to select breeding doe ranked by respondents.

Selection criteria	R1	R2	R3	I
Body size	22	2	0	0.10
Hair type	5	2	2	0.03
Coat colour	8	3	1	0.05
Coat colour pattern	5	0	1	0.02
Ears	11	2	0	0.05
Horns	8	1	1	0.04
Teats	12	3	1	0.06
Wattle	5	2	0	0.03
Beard	7	1	0	0.03
Birthing ease	11	2	0	0.05
Milk production	11	6	0	0.07
Mothering ability	11	5	2	0.07
Longevity	8	0	1	0.04
Twinning rate	13	1	1	0.06
Kid sex ratio (Male/Female)	2	1	1	0.01
Kid survival	7	2	0	0.04
Kidding interval (months)	8	2	3	0.05
Temperament	6	1	3	0.03
Growth rate	14	4	1	0.08
Disease resistance/survival	15	5	1	0.08
Total	189	45	19	1

R1=Rank 1; R2= Rank=2; R3=Rank 3; I=Index; I= sum of [3 for rank 1+2 for rank 2 + 1 for rank 3] given for a selection criterion divided by sum (3 for rank 1+ 2 for rank 2 + 1for rank 3) for all selection.

Table 2. Selection criteria of farmers to select breeding buck ranked by respondents.

Selection criteria	R1	R2	R3	I
Body size	13	0	0	0.22
Hair type	1	1	0	0.03
Coat colour	3	1	0	0.06
Coat colour pattern	3	1	0	0.06
Ears	4	1	0	0.07
Horns	4	1	0	0.07
Teats	0	1	0	0.01
Wattle	3	0	0	0.05
Beard	2	0	0	0.03
Early maturity	4	1	0	0.07
Temperament	1	1	2	0.04
Growth rate	8	2	0	0.15
Disease resistance/survival	9	0	1	0.15
Total	55	10	3	1

R1=Rank 1; R2= Rank=2; R3=Rank 3; I=Index; I= sum of [3 for rank 1+2 for rank 2 + 1 for rank 3] given for a selection criterion divided by sum (3 for rank1+2 for rank 2 + 1for rank 3) for all selection.

Ranked goats

Two hundred and ten goats were selected by farmers. Selected goats had body weight ranging from 12 (least ranked) to 60 kg (highly ranked) and 2 to 3 years of age. The average body weight of measured selected goats was 38.1±12.0 kg with a mean chest girth (CG) of 82.2±7.17. Average disease incidence for high ranked

Table 3. Overall descriptive statistic of selected goats (does and bucks) by Pella goat farmers.

Body measurement	N	Missing N	Mean	Std Dev	Minimum	Maximum
BW	176	34	38.08	12.00	12.00	60.00
CG	209	1	82.16	7.17	62.00	108.00
RL	176	34	23.27	9.16	16.00	90.00
RH	206	4	64.93	18.17	18.00	94.00
RW	209	1	23.16	4.40	9.00	49.00
SC	22	2	24.02	21.15	8.00	88.00
CB	209	1	13.15	2.00	9.00	20.00
WH	208	2	69.44	4.79	53.50	91.00
SH	174	36	49.00	4.36	35.00	75.00
BL	204	6	69.17	6.02	53.00	92.00

CG = Chest girth; RW = RL rump length; BW = body weight; RW = rump width; RH = rump height; SC = scrotum circumference; CB = canon bone; WH = withers height; SH = sternum height; BL = body length, N= sample size.

goats was 0.05±0.21. Table 3 illustrates overall descriptive statistics (mean, standard deviation, minimum and maximum) of selected goats.

Table 4 summarizes the statistical significance of sources of variation (sex, age and sex × age interaction) affecting body weight, body condition score and linear measurements of animals. Sex affected significantly ($p < 0.05$) CG, WH and BL. The effect of age was highly significant ($p < 0.01$) for BW, CG, RW, WH, SC, CB, WH, SH and BL. However, sex and age interacted significantly in all these parameters except for RL, RH, SC and BCS. There was no statistical effect of sex, age and sex × age interaction on body condition score of goats.

The Correlation Coefficients (r) between BW and body measurements are presented in Table 5. Eight out of nine measurements were significantly correlated with BW. Of these, CG had the highest correlation (r = 0.70) and SH had the lowest correlation (r = 0.28). RL was not significantly correlated with body weight. For BCS, the correlation coefficient was 0.20 ($p < 0.01$; n = 171).

DISCUSSION

Smallholder farmers in Pella village, North West province in South Africa keep their goats under extensive production system using indigenous knowledge and practices in animal management and breeding. The formation of community-based breeding program (CBBP) serves as a working model to increase productivity and improve the livelihoods of the farmers in this community. In the current study, it was observed that the elderly were more involved in goat farming and participate in the CBBP than the younger age groups. This finding is supported by a study by Musemwa et al. (2010), who also reported that the smallholder agricultural industry is currently dominated by old people, which raises concerns about the future of agricultural industry. Lack of youth participants entails failure in the transfer of indigenous knowledge from elders to the next generations (Lesoli, 2011). This important indigenous knowledge is thus at risk of becoming unknown (Lwoga et al., 2010). Majority of farmers in the study are literate as most of them received formal education (77.1%), 28.5% having received primary education (grade 1-7), 45.7% high school, and 2.9% tertiary education. Census (2011), conducted for Moses Kotane municipality revealed that 94.4% of people in the municipality can read and write. This makes it possible to train farmers on record keeping of important production parameters as an essential element in community-based breeding programs. Sixty percent of respondents depended on agriculture as the source of income. The head of the family who were predominantly fathers decided on all activities involving the herd as was observed in this study. These findings are supported by those of Swanepoel (2010) who observed that women and sons are given a chance to own livestock either through gift, inheritance or when they purchase their own animals. This sequence of ownership is likely to result on skewed asset distribution within family members. Farmers kept livestock more than crops, which is common for people in hot, humid areas due to weather conditions and soil fertility not good enough for crop production (Rust and Rust, 2013). This study revealed that farmers in the interviewed area keep goats more than other species, whilst studies done by Mdladla et al. (2017) observed that farmers kept cattle and chickens more than goats in the North West province. Ever since, more goat research and workshop have been conducted in the study area which could answer why the sample number of goat farmers has increased in this study compared to Mdladla et al. (2017) and Ncube et al. (2019). Majority of respondents practiced goat farming for income, home consumption (meat) and for savings. This suggested that goats have high financial and insurance functions in the study area. Other researchers also found that the main breeding objectives of smallholder farmers is for cash generation,

Table 4. Probability (*p*value) the effect of sex, age and the interaction of age and sex on body weight and linear body measurements.

Body measurement	Class		
	Sex	Age	Age and sex interaction
BW	0.2026ns	<0.0001	0.0181
CG	0.0346	<0.0001	0.0001
RL	0.5264^{ns}	0.4969^{ns}	0.6429^{ns}
RH	0.8245^{ns}	0.0957^{ns}	0.2033^{ns}
RW	0.5588^{ns}	0.0001	0.0111
SC	-	0.0019	-
CB	0.91^{ns}	<0.0001	0.0032
WH	0.0093	<0.0001	<0.001
SH	0.1384^{ns}	0.0016	0.0011
BL	0.0122	<0.0001	0.0011
BCS	0.1755^{ns}	0.2356^{ns}	0.228^{ns}

CG = Chest girth; RL= rump length; BW = body weight; RW = rump width; RH = rump height; SC = scrotum circumference; CB = canon bone; WH = withers height; SH = sternum height; BL = body length; BCS= body condition score. ns= Non-significant ($p > 0.05$); significant ($p < 0.05$).

Table 5. Correlation coefficients (r) between body weight and linear body measurements in Pella goats.

Body measurement	r	N
CG	0.70**	175
RL	0.03^{ns}	175
RH	0.45**	172
RW	0.31**	175
SC	0.67**	20
CB	0.50**	175
WH	0.40**	175
SH	0.28**	173
BL	0.43**	170

ns= Non-significant ($p > 0.05$); *$p < 0.05$, **$p < 0.01$, n had missing measurements.

home consumption and cultural activities (Bester et al., 2009; Dube et al., 2015; Mdladla et al., 2017). Cultural activity was not the main reason farmers keep goats in the study area.

The mean flock size of goats per household was 21±19 within Pella CBBP members while studies done by Mdladla et al. (2017) in the North West found 19.9±15.8 mean flock size per household. Mahlobo (2016) observed mean flock sizes of 17.4 ±1.94 in KwaZulu Natal, South Africa. The study confirmed the shortage of bucks in the rural communities of South Africa as does accounted forthe largest proportion of the herd. The study done by Mdladla et al. (2017) reported flocks with more adult goats and less kids. In that study, few bucks accounted for 28.6% and a ratio of breeding doe to breeding buck of 2:1 was observed. Bester et al. (2009) reported a doe:buck ratio of 11:1. Such skewed ratios pose a challenge in the reproductive performance of flocks with less bucks (Mueller et al., 2015). In the current study, goats started mating from/at 12 months while Mamabolo (1999) found that does in communal areas are ready for mating at 9 months. Majority of goats reached puberty at a relatively young age (from 4 months). Although there are considerable differences between should be separated by or before 5 months of age to control mating (Rogers et al., 1969). Frequent type of birth observed in this study was twins, while Lusweti (2000) reported 11% twin births in the Taung and Kudumane districts of the North West province of South Africa. Mating was uncontrolled in the flock as farmers allowed their buck to mate with close relatives (dam, sister and a daughter) and does from neighbors to increase their flock. However, this is not the ideal due to inbreeding, inbreeding depression and no genetic variation in the flock (Oldnbroek and Van der Waaij, 2014).

Major reasons for farmers to castrate their goats between 1 and 3 months at any season was the goat's temperament, larger bodies to fetch bigger market prices and if the animals display undesirable production traits. Farmers indicated the use of an elastic band to castrate their goats. Castration is recommended to be done to male kids less than three weeks of age if the buck will not be used for breeding purposes (Solaiman, 2010; DAFF, 2016; Leffan, 2018), 8-12 weeks if the buck is kept specifically for meat, while Smith (2010) recommends castration as early as one week of age. Culling was not practiced at Pella and the minority of farmers that did, practiced it to bucks with poor libido, old and those with bad physical condition. Farmers used culled goats for selling and to slaughter for meat consumption at home.

Selling price for larger (60 kg) goats was higher compared to the smaller ones (12 kg) even though sex, age and the interaction of both did not show any significant effect on the price but there was a significance ($p = 0.0001$) and fair correlation between body weight and price ($r = 0.40$). It was observed that males were sold with a higher price compared to females which translates that in the study area goat price was determined by how big and heavy the goat is. Even though heavier weight does not always translate to higher prices of goats for village farmers and consumers because people buy goats for different cultural reasons which might require qualities such as colour and height. For example, goats in the province of KwaZulu Natal are sold on height rather than on weight, a 22 kg and 50 cm high (shoulder height) will fetch a higher price than a 25 kg at 45 cm height. Farmers selling price was subjective, but it was observed that in most cases, the bigger the goat the more expensive it was, which led to farmers selling castrates and older goats first. Kayamandi (2006) observed that the best time to sell is between 6 and 8 months before sexual maturity and 1st kidding. During the kidding season, more production inputs may be required as goats require most care and nutrition (Gizaw, 2010). Farmers sold their goats amongst themselves within the community and did not participate in auctions or other marketing activities. Assistance in farm management is therefore important to enable farmers to expand to the markets. Goat meat contains less fat, cholesterol and higher levels of protein and iron than most other types of meat (Kayamandi, 2006). Such attributes could be promoted and improve the marketing potential for goat meat.

In the study area, majority of farmers do not provide concentrates and supplements for their goats and goats relied on grazing fallow land and browses. Extensive free grazing in communal grazing lands and browses are the most common practices of feeding goats (Dube et al., 2015; Mahlobo, 2016; Mdladla et al., 2017). It is estimated that natural pasture provides 80 to 90%, and crop residues 10 to 15% of the total livestock feed intake (Mengistu, 2006). Some communal farmers use supplements such as cassava peels, wheat bran, dry maize, silage, cut forage, and spent malt (Timpong-Jone et al., 2014). Some do not use these feeds because they are unavailable and expensive as seen in this study. It was reported by Gwelo (2013) that only 44% of the farmers provided their livestock with extra feed in the Eastern Cape province, South Africa. Nutrition is very important in pregnant does especially the last two months of pregnancy. Approximately, 70% of the weight of the kid(s) is developed from around day 100 to the birthing date. Undernourishment during this period will result in the birth of smaller kids, increased mortality and slower growth rates. The poor productivity of smallholder farmers may be associated with lack of supplementation which may directly or indirect affect reproduction and production of milk, meat and profit.

This study revealed that communal farmers predominantly kept goats for home consumption although there were records on the number animals slaughtered per year. Other uses were hides to make shoes and handbags, milk, although less common in the area. Goat milk is not only limited to sour milk as a by-product, it can also be utilized for making cheese or yoghurt (DAFF, 2016). Goats can be milked as often as needed but they have been reported to have low milk production sometimes not enough to provide for the needs of their kids (Kayamandi, 2006). Therefore, indigenous goats are not adequate for milk production.

About 34% of the farmers did not know the major goat diseases in their area and they used description of symptoms. This could be lack of knowledge, education about goat disease and veterinary support. Diseases and parasites are the major constraints to improve small ruminant production and productivity in most production systems (Gizaw, 2010). Health problems cause high mortality and reduced reproductive and growth performances resulting in reduced output per animal and flock off-take rates (Caleni, 2017). The warm and/hot, moist climates favour the propagation of external parasites that affect goats, also such areas are known to have droughts which directly affects grazing fields supplements such as Lucerne and others which are vital in such conditions. But because they are expensive for communal farmers, livestock end up dying of starvation and thirst. The North West experienced drought for almost 6 months during the year 2015 to 2016 which caused loss in agriculture at large (Kubheka and Malgas, 2016). People from the North West suffered during this period as agriculture is their main economic activity, the impact was seen in the form of reduction in food production, reduced water levels, increased livestock and wildlife deaths and more. Therefore, goat farming is suitable in this area because of their adaptability to such harsh conditions.

The results on trait preferences showed that body size, fast growing and disease resistance are highly ranked and preferred by farmers for both does and bucks. These results are supported by Abraham et al. (2014), Ahmed et al. (2015), Gizaw et al. (2013), Nandolo et al. (2016), Lorato et al. (2015) and Karnuah et al. (2018) who observed that body conformation was the highly ranked selection criterion among goat farmers. Higher preference values of body size for breeding animals were reported by similar studies in Ethiopia and other tropical areas (Jaitner et al., 2001; Duguma et al., 2011; Berhanu et al., 2012; Kebede et al., 2012). Growth rate and disease resistance traits were of equal importance to farmers as these traits had equal ranking index for both does and bucks. The plausible reasons as perceived by the respondent for these preferences were that strong goats have more meat and are healthier as a result such goats will be sold with a much better price. Interaction with respondents revealed that castrated males fetch high market price than intact bucks. This persuaded farmers to castrate their bucks at an early stage for fattening resulting in a shortage of breeding bucks and small flock size challenge among farmers. Before castration a buck is not genotyped or assessed for any characteristics because the reason castration is solely for fattening. So, there is a chance that a castrated buck may carry important traits that would be good for the flock in terms of characteristics and production traits. Farmers showed more interests in farming for a profit thus it is necessary to implement an appropriate breeding program that will improve growth traits in Pella prevailing system. Also, genetic improvement could contribute to bridging the productivity gap by genotyping animals for most important economic trait that farmers prefer. Mothering ability, milk production, twinning rate (reproductive traits) and fitness trait (disease resistance) for does should all be considered when designing a sustainable breeding program for this community. Early maturity, ears, horns, coat color and coat color patterns were among preferred trait for bucks, all these traits should be taken into consideration too.

The Mubende indigenous goat breed from the Kabale and Bundibugyo districts of Uganda are reared for meat with average body weights of 31.5 kg for female and 35.7 kg for male goats. Pella goats can also be reared for meat as their average body size was 37.7 kg for does and 40.4 kg for bucks. The observed high average body weight in bucks than does may be due to relatively large physical features of the male as a result of natural hormonal variation (Mahmud et al., 2014). Even though there was no sex effect (p = 0.2026) on body weight in this study, other studies previously reported significant effect of sex on body weight (Fasae et al., 2005; Afolayan et al., 2006; Musa et al., 2006). However, high significance was observed with age on body weight also, there was significance on the interaction of sex and age on body weight. There was significantly high effect of age on BW, CG, CB, WH and BL (p < 0.0001). Age did not have effect on RL, RH and BCS. This scenario is however surprising since the size and shape of the animal are expected to increase as the animal is growing with age. Supported by other studies done by Fajemilehin and Salako (2008), DeVilliers et al. (2009), Getachew et al. (2009) and Olawumi and Farinnako (2017) on indigenous goats. The interaction between age and sex influenced most body measurements except for RL, RH and BCS. There were no values for SC because there were few males, but age effect on SC was observed. All linear body measurements studied were significantly correlated with body weight except for RL. BCS in this study was not significantly linked with all the fitted variables and it showed no correlation with body weight either. Body condition scoring is a management tool that can be used to evaluate the nutritional status of animals and it is an indication of the energy reserves in an animal and this study has shown that it has nothing to do with age or sex of an animal. Chest girth showed the highest correlation coefficient (0.70) with body weight compared to other body measurements. These results agree with other results (De Villers et al., 2009; Getachew et al., 2009; Olawumi and Farnnako, 2017). Thus, this would imply that chest girth was the best variable for predicting live body weight than other measurements. The higher association of body weight with chest girth could be attributed to the relatively larger contribution in body weight by chest girth, which consists of bones, muscle and viscera (Moela, 2014). Scrotum circumference also had high correlation with body weight, these findings need to be evaluated more and include different age group because it was found that males with larger SC sire daughters that reach puberty earlier and ovulate more (Getachew et al., 2009). Thus, measurement of SC can be an essential part in breeding and selection evaluation for reproduction traits. CB (0.50), WH (0.40) and BL (0.43) show fair correlation and can also be used as indirect selection criteria to improve live body weight.

Conclusion

The study showed that goat farming is the major activity farmers practice especially in the study area, consequently indicating that improvement is necessary. Action is needed to minimize the risk of inbreeding depression as a buck can mate his close relatives. There is a need for farmers to practice record keeping such as entrance and exit, births, deaths, sold and slaughtered animals for management. Pella farmers have limited access to vaccines from the government, no equipment for fencing, supplements, and ways to control theft and disease infestations. Therefore, there is a necessity for extension service to be more involved in assisting communal farmers in this area. Body size, growth rate and disease resistance were highly ranked breeding objectives. Farmers preferred many traits like production traits (growth rate), fitness traits (disease resistance), adaptive traits (ears and horns) and type traits (coat colour, and coat colour pattern). The preference of big body size and fast growth is expected when the main purpose of keeping goat is for cash income. When designing sustainable breed improvement strategies in this production system, mechanisms to include all categories of traits should be considered. Body weight measurement is essential for any breeding and selection programme in livestock industry. The findings of this study revealed that chest girth was the best predictor of body weight and the least predictor was rump length.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Abraham H, Gizaw S, Urge M (2018). Identification of breeding objectives for Begait goat Western Tigray, North Ethiopia. Tropical Animal Health and Production 50(8):1887-1892.

Afolayan R, Adeyinka I, Lakpini C (2006). The estimation of live weight from body measurements in Yankasa sheep. Czech Journal of Animal Science 51(8):343.

Ahmed S, Kefelegne K, Kefena E (2015). Breeding Objective, Selection Criteria and Breeding Practice of Indigenous Goats in Western Ethiopia: Implications for Sustainable Genetic Improvement. Greener Journal of Agricultural Sciences 5(5):167-176.

Berhanu T, Thiengtham J, Tudsri S, Abebe G, Tera A, Prasanpanich S (2012). Purposes of keeping goats, breed preferences and selection criteria in pastoral and agro-pastoral districts of South Omo Zone. Livestock Research for Rural Development 24(12):20.

Bester J, Ramsay K A, Scholtz MM (2009). Goat farming in South Africa, findings of a national livestock survey. Applied Animal Husbandry and Rural Development 2:9-13.

Bhuiyan MSA, Bhuiyan AFH, Lee JH, Lee SH (2017). Community based livestock breeding programs in Bangladesh: Present status and challenges. Journal of Animal Breeding and Genomics 1(2):77-88.

Caleni S (2017). Assessing the Socio-Economic impact of drought in Goegevonden village, Ventersdorp Local Municipality in North West Province South Africa. Masters Thesis. University of the Free State.

Census (2011). Agricultural households: Statistics South Africa. http://www.statssa.gov.za/publications/Report-03-11-01/Report-03-11-012011.pdf.

Dana N, Vander Waaij E, Van Arendonk JA (2011). Genetic and phenotypic parameter estimates for body weights and egg production in Horro chicken of Ethiopia. Tropical Animal Health and Production 43(1):21-28.

Department of Agriculture Forestry and Fisheries, DRDP (2016). Abstract of agricultural statistic. https://www.daff.gov.za/daffweb3/home/crop-estimates/statistical-information.

De Villiers J, Gcumisa ST, Gumede SA, Thusi SP, Dugmore T, Cole M, Toit JF, Vatta AF, Stevens C (2009). Estimation of live body weight from the heart girth measurement in KwaZulu-Natal goats. Applied Animal Husbandry and Rural Development 1(2):1-8.

Duguma G, Mirkena T, Haile A, Okeyo AM, Tibbo M, Rischkowsky B, Sölkner J, Wurzinger M (2011). Identification of smallholder farmers and pastoralists preferences for sheep breeding traits: choice model approach. Animal 5(12):1984-1992.

Dube K, Muchenje V, Mupangwa JF (2015). Characterization of goat production systems in selected coastal areas of the Eastern Cape Province, South Africa. Master Thesis. University of Fort Hare.

Fajemilehin OS, Salako A (2008). Body measurement characteristics of the West African Dwarf (WAD) goat in deciduous forest zone of South Western Nigeria. African Journal of Biotechnology 7(14):2521-2526.

Fasae O, Chineke A, Alokan J (2005). Relationship between some physical parameters of grazing Yankasa ewes in the humid zone of Nigeria. Archivos de zootecnia 54(208):639-642.

Gebreyesus G, Haile A, Dessie T (2013). Breeding scheme based on community-based participatory analysis of local breeding practices, objectives and constraints for goats around Dire Dawa, Ethiopia. Livestock Research for Rural Development 25(3):48.

Getachew T, Haile A, Tibbo M, Sharma A, Solkner J, Wurzinger M (2009). Use of linear body measurements for performance recording and genetic evaluation of Menz and Afar sheep breeds under village condition. Paper presented at the Proceedings of the 17th Annual Conference of the Ethiopian Society of Animal Production held in Addis Ababa, Ethiopia.

Getachew T, Haile A, Rischkowsky B (2018). How to tailor community-based breeding programs for small ruminants to pastoral production systems. Paper presented at the Proceedings of the World Congress on Genetics Applied to Livestock Production.

Gizaw S (2010). Sheep and goat production and marketing systems in Ethiopia: Characteristics and strategies for improvement. Improving Productivity and Market Success of Ethiopian Farmers Project, Working Paper (23):58.

Gizaw S, Getachew T, Edea Z, Mirkena T, Duguma G, Tibbo M, Wurzinger M (2013). Characterization of indigenous breeding strategies of the sheep farming communities of Ethiopia. InternationalCenter for Agricultural Research in the Dry Areas, Working paper.

Greene JW, Silverstein J (2012). USDA Agricultural Research Service in Food and Nutrition Research and Science. https://www.usda.gov/media/blog/2012/03/27/usda-science-support-feed-future-and-global-food-security.

Gwaze F, Chimonyo M, Dzama K (2009). Communal goat production in Southern Africa: a review. Tropical Animal Health and Production 41:1157-1168.

Gwelo FA (2013). Farmers' Perceptions of Livestock Feeding and Rangeland Management; Dynamics of Soil, Forage and Cattle Blood Serum Mineral Levels in Two Communal Areas in the Eastern Cape, South Africa. University of Fort Hare.

Karnuah AB, Rewe T, Dunga G (2018). Community based breeding program for improve goat production in Liberia. Malaysian Orthopaedic Journal Current Research & Reviews 1(5):216-221.

Kayamandi Development Services (2006). Goat meat production feasibility study http://www.lepelle-nkumpi.gov.za/lepelle-nkumpi-admin/pages/sites/lepellenkumpi/documents/strategies/GOAT%20FARMING%20FEASIBILITY.pdf.

Kebede T, Haile A, Dadi H (2012). Smallholder goat breeding and flock management practices in the central rift valley of Ethiopia. Tropical Animal Health and Production 44(5):999-1006.

Jaitner J, Sowe J, Secka-Njie E, Dempfle L (2001). Ownership pattern and management practices of small ruminants in The Gambia-implications for a breeding programme. Small Ruminant Research 40(2):101-108.

Kosgey I, Baker R, Udo H, Van Arendonk JA (2006). Successes and failures of small ruminant breeding programmes in the tropics: a review. Small Ruminant Research 61(1):13-28.

Kubheka T, Malgas (2016). Drought-stricken Swartruggens community longs for running water http://ewn.co.za.

Leffan J (2018). Dairy goats: Ag guide-a practical handbook. https://www.agrifutures.com.au/product/fact-sheet-dairy-goats-a-practical-handbook.

Lesoli MS (2011). Characterisation of Communal Rangeland Degradation and Evaluation of Vegetation Restoration Techniques in the Eastern Cape, South Africa. Masters Thesis. University of Fort Hare.

Lorato Y, Ahmed KM, Belay B (2015). Participatory Characterization of the Woyto-Guji goat and its production environment around Northern Omo, Ethiopia. Journal of Agriculture and Natural Resources Sciences 2(2):455-465.

Lusweti E (2000). A survey of goat production in the developing areas of the North West province of South Africa. South African Journal of Animal Science 30(1):34-35.

Lwoga ET, Ngulube P, Stilwell C (2010). Understanding indigenous knowledge: Bridging the knowledge gap through a knowledge

creation model for agricultural development. South African Journal of Information Management 12(1):8.
Mahlobo BT (2016). Multi – criteria livestock assessment for sustainability of smallholder farms in Kwa-Zulu Natal. Masters Thesis. Stellenbosch University.
Mamabolo MJ (1999). Effects of Dietary Seasonal and Environmental Factors on the Fertility Status and Semen Quality of Indigenous Goats in Mpumalanga. Masters Thesis. University of Pretoria.
Marshall K, Gibson JP, Mwai O, Mwacharo JM, Haile A, Getachew T, Kemp SJ (2019). Livestock genomics for developing countries-African examples in practice. Frontiers in genetics 10:297.
Mengistu A (2006). Country pasture/forage resource profiles. FAO. Roma, Italia.
Mirkena T (2010). Identifying breeding objectives of smallholders/pastoralists and optimizing community-based breeding programs for adapted sheep breeds in Ethiopia. PHD Thesis. University of Natural Resources and Life Sciences, Vienna.
Moela AK (2014). Assessment of the relationship between body weight and body measurement in indigenous goats using path analysis. Masters Thesis. University of Limpopo, Turfloop.
Morrison JW (2007). A guide to the identification of the natural African indigenous veld goats of Southern Africa. Compiled for the Indigenous Veld Goat Breeders Society, Pretoria, South Africa.
Mahmud MA, Shaba P, Abdulsalam W, Yisa HY, Gana J, Ndagi S, Ndagimba R (2014). Live body weight estimation using cannon bone length and other body linear measurements in Nigerian breeds of sheep. Journal of Advanced Veterinary and Animal Research 1(4):169-176.
Musemwa L, Mushunje A, Chimonyo M, Mapiye C (2010). Low cattle market off–take rates in communal production systems of South Africa: causes and mitigation strategies. Journal of Sustainable Development in Africa 12(5):209-226.
Mueller JP, Rischowsky B, Haile A, Phillipsson J, Mwai, O, Besbes B, Valle A, Tibbo A, Mirkena T, Duguma G, Solkner J, Wurzinger M (2015). Community-based livestock breeding programmes: essentials and examples. Journal of Animal breeding and Genetics 132:155-168.
Musa HH, Amin El, Suleiman FM, Chen AH, Olowofeso GH, Mekki DM (2006). Body measurements in West African sheep in Sudan. Journal of Animal and Veterinary Advances 5(4):289-300.
Mdladla K, Dzomba EF, Huson H, Muchadeyi FC (2016). Population genomic structure and linkage disequilibrium analysis of South African goat breeds using genome-wide SNP data. Animal Genetics 47:471-482.
Mdladla K, Dzomba EF, Muchadeyi FC (2017). Characterization of the village goat production systems in the rural communities of the Eastern Cape, KwaZulu-Natal, Limpopo and North West Provinces of South Africa. Tropical Animal Health and Production 49(3):515-527.
Nandolo W, Wurzinger M, Mészáros G, Van Tassell C, Gondwe T, Mulindwa H, Sölkner J (2016). Identification of breeding objectives in community-based goat breeding programmes in Malawi. Acta Agriculturae Slovenica 5:104.
Oldnbroek A, Van der Waaij, L (2014). Textbook animal breeding Animal breeding and genetics for BCS students. Centre for Genetic Resources and Animal Breeding and Genomics Group. Wageningen University and Research Centre, the Netherlands.
Olawumi S, Farinnako A (2017). Evaluation of the relationship between body weight and linear measurements in West African dwarf goat as influenced by sex and agro-vegetational zone. Science International 5(2):63-67.
Rogers A, Erickson L, Hoversland A, Metcalfe J, Clary F (1969). Management of a colony of African pygmy goats for biomedical research. Laboratory Animal Care 19(2):181.
Rust JM, Rust T (2013). Climate change and livestock production: a review with emphasis on Africa. South African Journal of Animal Science 43(3):256-267.
Sebei PJ, McCrindle CME, Webb EC (2004). An economic analysis of communal goat production. Journal of the South African Veterinary Association 75(1):50-54.
Silanikove N, Koluman N (2015). Impact of climate change on the dairy industry in temperate zones: predications on the overall negative impact and on the positive role of dairy goats in adaptation to earth warming. Small Ruminant Research 123(1):27-34.
Statistical Analysis System (SAS) (2014). SAS Version 9.2 User's Giude, SAS Institute Inc, Cary, North Carolina, United State of America.
Solaiman SG (2010). Goat Science and Production. Publication: Blackwell Publishing, Hoboken.
Swanepoel F, Stroebel A, Moyo S (2010). The role of livestock in developing communities: enhancing multifunctionality. University of the Free State and the Technical Centre for Agricultural and Rural Cooperation.
Timpong–Jones EC, Adogla–Bessa T, Adjorlolo LK, Sarkwa FO (2014). Some constraints of ruminant livestock production in the Coastal Savannah Plains of Ghana. Livestock Research for rural Development 26(5):2014.
Weaver TT (2013). Trade Research and ScienceTechnology, https://www.usda.gov/media/blog/2013/04/30/using-data-change-world-one-goat-time.
Visser C, Van Marle-Köster E (2018). The Development and Genetic Improvement of South African Goats: in goat Science. IntechOpen.