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Performance of goats and sheep under communal grazing in Botswana using various growth measures

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ABSTRACT

We conducted a survey to evaluate the growth of goats and sheep under communal grazing, and to determine the relationship between weight, heart girth, shoulder height, and body condition score in Kweneng, Central and Kgalagadi districts, Botswana. The same animals were measured on two separate occasions, approximately one month apart, to allow growth rates to be recorded. Significant differences in growth rates between the three case study districts were found for both goats and sheep. Amongst the goats measured, gains in height and weight were significantly greater in the Kweneng district, while gains in heart girth measurement were greatest in the Central district. In the case of sheep, weight gain was significantly higher in the Central and Kgalagadi districts, increases in girth measurement were significantly higher in the Central district, and shoulder height gain was significantly greater in the Kweneng district. Statistical tests were used to determine the relationships between animal weight and the other measures taken for goats and sheep. Heart girth in both goats and sheep was shown to be a significant predictor of weight across all three districts. Likewise, shoulder height proved to be a statistically significant predictor of animal weight for both goats and sheep, across each district. The data therefore suggest that heart girth and shoulder height have potential to act as proxy measurements of weight in both goats and sheep, potentially providing smallholder farmers with a cost-effective way of estimating small-stock productivity.

Keywords Tswana goats, Tswana sheep, growth performance, heart girth.

PAPER

1. Introduction

Small-stock such as goats and sheep play a vital role in the livelihood of smallholder farmers in rural Botswana. The goat population in Botswana was estimated to be 1.6 million in 2013, and the sheep population at just under 300,000 (Statistics Botswana, 2015). Just about all goat and sheep production in Botswana takes place in the traditional smallholder sector, with commercial livestock production focusing mainly on cattle (Burgess 2006). The indigenous Tswana breed accounts for the majority of goats and sheep owned by farmers. Goats and sheep are raised mainly for domestic consumption of meat, milk, hides, for income generation, and for other social activities like payment of dowry (Aganga & Aganga 2015).

Small-stock in Botswana are mostly commonly managed in communal grazing areas, where fencing is not permitted (Nsoso et al. 1999). Most local farmers allow their goats, sheep and cattle to browse on tree forages in the rangelands. They may also periodically cut tree branches or harvest tree pods, to use as feed supplements (Aganga & Autlwetse 2000).

However, most smallholder farmers in Botswana invest relatively little in supplementary feeding, labour, and disease and parasite control for their goats and sheep. Although in the case of supplementary feed this may be partly due to irregularity of fodder production arising from variable weather conditions (Burgess 2006), the result of this lack of investment is to hinder the productivity of small-stock. Lack of availability of accurate scales makes it difficult for smallholder goat and sheep producers to gauge the productivity of their animals (ESGPIP 2009). In this study, we therefore sought to evaluate the growth performance of goats and sheep under a communal grazing system, and to determine the relationship between weight, heart girth, shoulder height, and body condition score, by repeated measurement of these characteristics in a sample of animals. A key objective of the study was to determine the extent to which heart girth, shoulder height and body condition score may be used as proxy measures of goats and sheep weight.

2. Materials and Methods

2.1 Study Area

The study was conducted from September through to November 2015 in Kweneng and Kgalagadi districts in the south and south-west of Botswana, and Central district in eastern Botswana. The climate in the Kweneng district is classified as semi-arid, and is influenced by the local steppe. Average annual temperature is 19.6°C, and average annual rainfall is 455 mm (Climate-Data.Org 2016). In the Central district the climate is semi-arid. Average annual temperature is 20.4°C, and average annual rainfall is 452 mm (Climate-Data.Org 2016). The Kgalagadi district is classified as having a desert climate.

2.2 Description of goats and sheep

The Tswana goats are a large horned, multicoloured, medium size breed, with lopping ears, a short course hair structure, and are predominantly bearded and horned (Katongole et al. 1996, Podisi, 1999). Tswana sheep have a well developed fat tail, hairy coat, and are usually white or black and white in colour (Nsoso et al. 1999).

2.3 Small-stock management and data collection

Goats and sheep measured during the project, across all farms and in all three districts, were ear tagged for repetitive collection of data during the study period. All goats and sheep in sampled farms aged "one year and below" were selected for the study. Farmers usually released the goats and sheep between 1000hrs and 1100hrs to forage in communal grazing areas. The small-stock were returned to the „kraals" (fenced enclosures) in the evening. In each farm, initial measurements (weight, girth and shoulder height) were taken before the goats or sheep were released for grazing. A second series of measurements were taken approximately four weeks after initial measurement, to allow a determination of growth rate to be made.

2.4 Statistical analysis

In order to determine the growth rates of livestock for each animal the first measurement of each of these characteristics was subtracted from the second measurement, resulting in three figures for change in weight, heart girth measurement and shoulder height measurement respectively. In order to determine the relationship of different measures of sheep and goat size, analysis of variance (ANOVA) of fixed effects was carried out using the General Linear Model (GLM) procedures of the Statistical Analysis System software package (SAS, 2010). The fixed effects considered were animal type (sheep or goat) and district (Kweneng, Central or Kgalagadi). Initial animal weight was used as a covariate variable. The response variable analysed were weight, heart girth measurement, shoulder height measurement, and body condition score[1]. Simple regression analysis was used to determine the relationship of weight, heart girth, shoulder height, and body condition score. A linear trendline was fitted to each scatterplot. All tests were considered significant at a $P<0.05$ level.

3. Results and Discussion

Data analysed for both goats and sheep showed that district and sex interactions with the variables were not significant, although growth rates measured amongst female goats and sheep alike were smaller than amongst male goats and sheep. Likewise, there was a poor relationship between weight and body condition score, as a potential proxy estimate of animal weight. Consequently, these results are not reported.

Feed availability for grazing animals play a significant role in determining growth performance. Grazing animals like cattle, goats and sheep will usually selectively graze in communal areas when released. Therefore, if forage quantity is limited then selection of the best forages or plant parts by the animal is limited (Zalesky 1997). In an accompanying study of sample communal pastures in the three case study districts (Kgosikoma, unpublished data), Kgalagadi district had the highest grass biomass, at 154kg/ha for good species and 187.50kg/ha for intermediate species. The Kweneng district had the least grass biomass, at 1.48kg/ha for good grass species, and 7.26kg/ha for intermediate grass species. Grass palatability was also most likely to be estimated as intermediate or poor in this district. The population of small shrubs (<0.5m to <1m in height) was highest in Kweneng at 1700 plants/ha and lowest at Kgalagadi with 150 plants/ha. Larger shrubs (>1m to <2m in height) were present in more dense populations in the Central and Kweneng districts, at 700 plants/ha.

[1] Body condition score (BCS) is used as an assessment of the fat reserves of livestock, and involves a physical assessment of fat coverage around the lumbar vertebrae, breastbone, and rib cage (eXtension.org 2009; New South Wales, Department of Agriculture, Agrifact A2.23). A scale of 1 to 4 was used for this research. BCS scores of 1.0 to 2.0 indicate a management or animal health problem. BCS scores of 2.5 to 4.0 indicate a healthy animal in most cases (eXtension.org 2009).

3.1 Growth rates of goats and sheep

The monthly weight gain of goats in the Kweneng district was significantly greater than the other districts (2.19kg; Table 1). The monthly weight gains for goats in the Kgalagadi and Central districts were not significantly different, at 1.97kg and 2.01kg respectively (Table 1). In previous controlled experiments carried out in Botswana (Aganga et al. 1998, Aganga et al. 2000, Aganga et al. 2001) the monthly weight gain of Tswana goats ranged from 0.9kg to 2.4kg, based on a diet of Buffalo grass supplemented with browse species. In these experiments, goats whose diets were supplemented with either lucerne or lablab gained 2.1kg monthly. These results were comparable to the results of our study. In rangelands, goats tend to prefer woody species over grass species. Mphinyane et al. (2015) reported that the diet of goats comprised 72% „browse" consumption in summer, with this proportion increasing to 82% in spring. The higher growth performance of goats in the Kweneng district suggests that a browse-dominant diet appears to be rich in minerals and protein (Le Houerou, 1980, Aganga et al. 2000), and is generally a more significant source of minerals and protein during dry seasons and drought periods (Dambe et al. 2015). According to Devendra (1980) goats are opportunistic foragers, and can maintain a high quality diet under different ecological zones. This was reflected at the Kgalagadi district where the plant population per hectare was the lowest of the three case study districts (↓ 300 plants/ha). Despite this, the goats managed to survive from ample grass that was denser in this district in communal grazing areas than in the other two case study districts surveyed for the study.

Table 1 - Monthly growth parameters of goats browsing natural pastures in communal areas across three districts of Botswana

	Kweneng[1]	Kgalagadi[2]	Central[3]	P-value
Height gain (cm)	3.21±0.21	1.98±0.16	1.89±0.20	*0.0001*
Girth gain (cm)	3.31±0.23	1.99±0.18	6.01±0.21	*0.0001*
Weight gain (kg)	2.19±0.08	1.97±0.06	2.01±0.08	*0.019*

[1] Number of observations in Kweneng; 372. [2] Number of observations in Kgalagadi; 620. [3] Number of observations in Central; 439. ± refers to standard error of the mean (S.E.M).

Height gain was significantly greater amongst goats in the Kweneng district than in the other two districts (3.21cm; Table 1). Browse utilization is dependent on accessibility for foraging animals. Livestock can only fully utilise browse material from plant heights that are within their reach (Le Houerou 1980). Hence, goats in the Kweneng district may have displayed better weight gain because they were able to access browse material from the greater diversity and quantity of shrubs that were within reach, compared to the other two districts where shrub density was not as great. The monthly weight gain of sheep was significantly higher in the Mahalapye and Kgalagadi districts (Table 2; 2.75kg and 2.91kg respectively; Table 2). In Kgalagadi, this may be attributable to the high grass biomass of 341kg/ha for good and intermediate species combined. In Mahalapye, sheep may have benefited from a combination of seedlings (<0.5m) which had a population count of 1200/ha, and grass biomass of 30kg/ha for good and intermediate species combined. Sheep in the Kweneng district gained the least weight, perhaps because most of the shrubs in the area were not within their reach. In this regard the sheep may only have benefited from fallen tree leaves as they drop naturally from trees, and by that stage the feed value of the leaves may have reduced (Dambe et al. 2015).

Table 2 - Monthly growth parameters of sheep browsing natural pastures in communal areas across three districts of Botswana

	Kweneng[1]	Kgalagadi[2]	Central[3]	*P-value*
Height gain (cm)	2.97±0.2	1.65±0.49	1.53±0.37	*0.033*
Girth gain (cm)	-0.15±0.62	0.82±0.25	5.52±0.43	*0.0001*
Weight gain (kg)	1.53±0.29	2.75±0.12	2.91±0.22	*0.0002*

[1] Number of observations in Kweneng; 63. [2] Number of observations in Kgalagadi; 378. [3] Number of observations in Central; 109. ± refers to standard error of the mean (S.E.M).

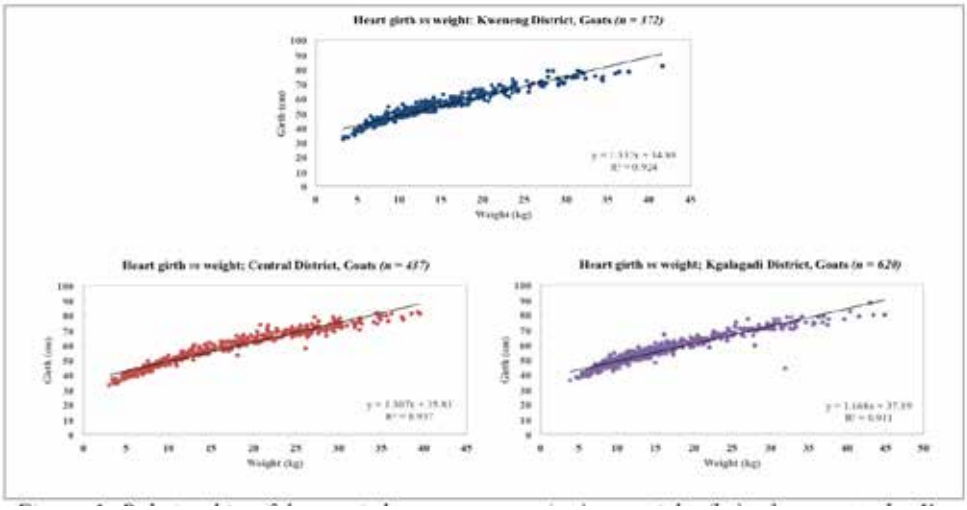
Similarly, since cattle and sheep are primarily grazers, both livestock species are more likely to be negatively impacted by drought or extended dry periods, because herbaceous plants are more sensitive to periodic moisture stress than wood plants (Mphinyane et al. 2015). Unlike goats in the Kweneng district, sheep gained relatively less weight, since their inability to forage from a bipedal stance from higher plants (as goats do) meant they did not have access to much of the woody plant material on communal grazing lands in this district. Nonetheless, height gain was significantly greater (3.21cm; Table 1) amongst sheep in the Kweneng district than the other two districts, showing that there was not necessarily a correlation between the extent of height gain and weight gain across the three districts.

3.2 Relationships of growth measures

3.2.1 Relationship of heart girth measurement to weight

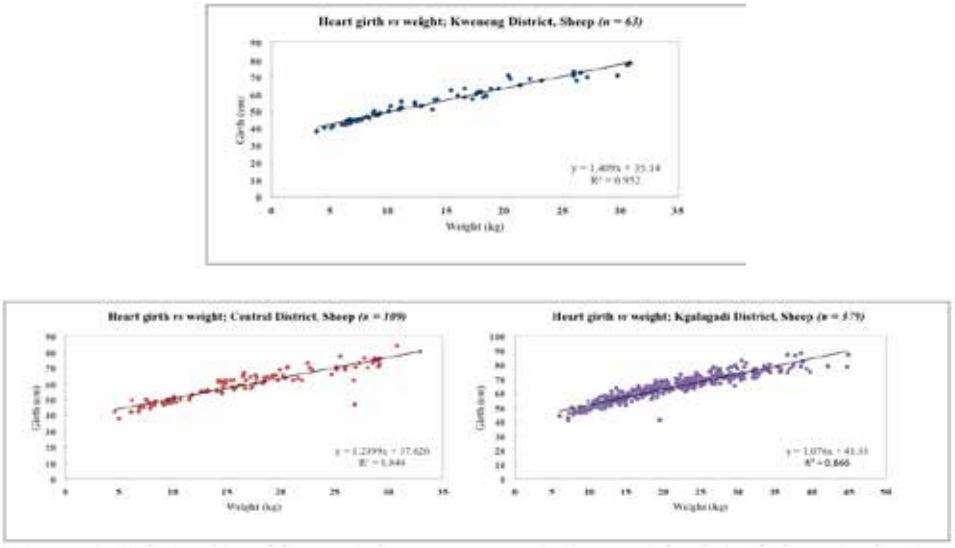
Data on body condition score showed no statistically significant relationships with weight in both goats and sheep, and consequently the results are not presented. Heart girth measurement in goats appears to be a statistically significant predictor of weight in the Kweneng, Central and Kgalagadi districts (R2=0.92, R2=0.95 and R2=0.91 respectively; Figure 1). As this Figure shows, heart girth measurement accounted for a large amount of the variability associated with animal weight across the sample of goats measured.

Figure 1 - Relationship of heart girth measurement (cm) to weight (kg) of goats in the Kweneng, Central and Kgalagadi districts, Botswana



As was the case with goats, heart girth measurement in sheep was highly correlated to weight in Kweneng, Central and Kgalagadi districts (R2=0.95, R2=0.85 and R2=0.87 respectively; Figure 2). Once again, heart girth measurement accounted for a large amount of the variability associated with animal weight across the sample population.

Figure 2 - Relationship of heart girth measurement (cm) to weight (kg) of sheep in the Kweneng, Central and Kgalagadi districts, Botswana



3.2.2 Relationship of shoulder height measurement to weight

As was the case with heart girth measurement, the shoulder height of goats in the sample showed a strong correlation with weight in Kweneng, Central and Kgalagadi districts (R2=0.82, R2=0.87 and R2=0.72 respectively; Figure 3).
In sheep, shoulder height also proved to be a strong predictor of weight in Kweneng, Central and Kgalagadi districts (R2=0.76, R2=0.79 and R2=0.62 respectively; Figure 4.).

Figure 3 - Relationship of shoulder height measurement (cm) to weight (kg) of goats in the Kweneng, Central and Kgalagadi districts, Botswana

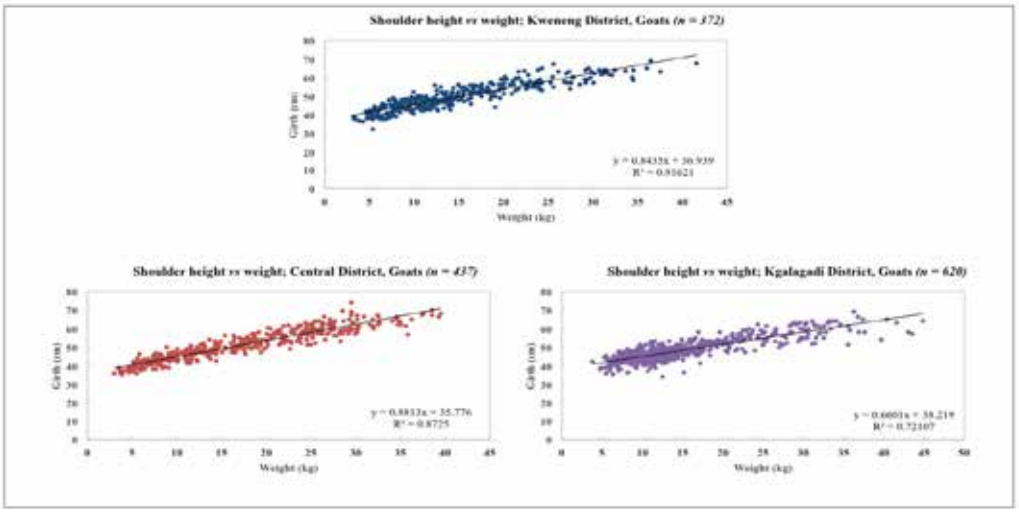
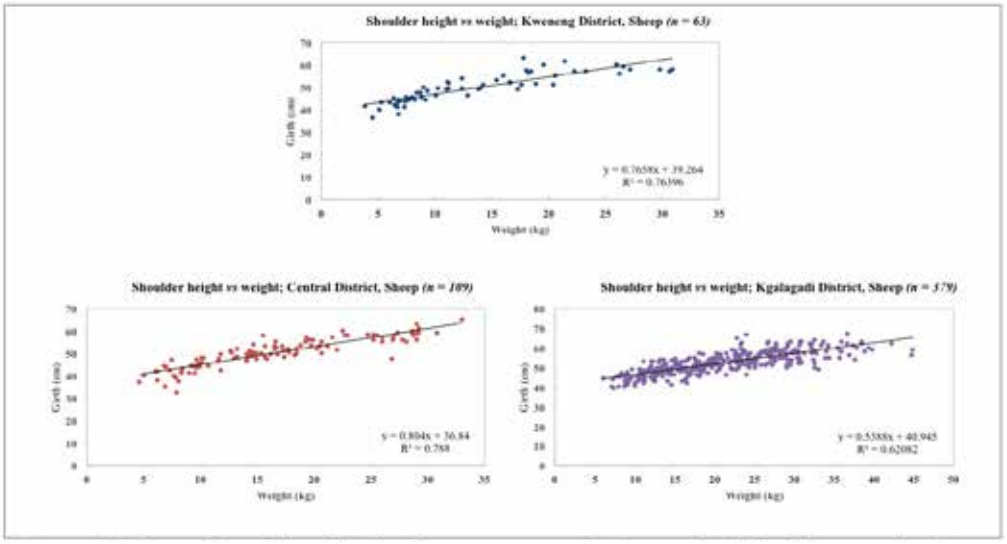


Figure 4 - . Relationship of shoulder height measurement (cm) to weight (kg) of sheep in the Kweneng, Central and Kgalagadi districts, Botswana



4. Conclusions

The results suggest that goats performed well in the Kweneng district, as a result of a high population density of browse species (particularly small shrubs). Previous research has suggested that small shrubs are the preferred source of feed for goats in Botswana during the dry season (Omphile et al. 2004). Sheep tended to perform well in Kgalagadi and Central districts, due to the relatively high grass biomass observed in these districts. Both heart girth measurement and shoulder height measurement appeared to be consistent and statistically robust predictors of weight in all the three districts in this study. As has been suggested in previous studies conducted elsewhere (e.g. ESGPIP 2009, Cam et al. 2010, Musa et al. 2012), heart girth appeared to be a better proxy measure of weight than shoulder height, however both can be used in a complementary fashion to estimate the weight of goats and sheep under communal grazing.

Future research in determining the potential for linear measurements to act as proxy measures for small-stock weight may involve expanding data collection to fully-grown animals, or those over 12 months of age, providing a sample of animals of known age could be identified. Likewise, data on breed may be collected for each animal measured to allow potential differences in weight, heart girth and shoulder height measurements by breed to be identifed.

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