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The Foraging Ecology of Nguni and Brahman Cattle under Different Management Systems in High-Altitude Grasslands of South Africa

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Abstract. Cattle production is important to both communal livelihoods and the national economy of South Africa. Understanding the foraging ecology of cattle is important for managing both the animals and their rangelands. This paper reports the dietary preferences of Nguni cattle under holistic management and Brahman cattle under conventional management at two farms during both the wet and dry seasons in high altitude grasslands of South Africa. Foraging patterns were monitored through focal sampling from June 2015 to January 2016. We found that dietary utilization and selectivity varied between the wet and dry seasons for both Nguni and Brahman cattle and both breeds showed strong preferences for certain plant species. In the dry season, Nguni selected strongly for the grass *Eragrostis plana*. Brahmans selected high value grass species, particularly *Sporobolus fimbriatus*, *Panicum ecklonii*, *Pennisetum clandestinum*, and *Themeda triandra*, which they continued to utilize in nearly the same proportions in the dry season, even though these grasses were not as widely available as in the wet season. This study suggests that cattle breed may influence foraging ecology and highlights the need for future research on how this interacts with management. Furthermore, our results suggest that due to their greater flexibility in diet and reduced reliance on supplementary feed, Nguni cattle may be particularly well-suited to this heterogeneous landscape with a marked dry season when resources are scarce.

Key words: Forage selection, Free-range management, Holistic management, Pasture, Rangelands

Introduction

Livestock production is globally important for both economic activity and rural livelihoods, particularly in the developing world (Thornton *et al*., 2002). Rangelands are spatially and temporally heterogeneous, disturbance-driven biomes (Fuhlendorf *et al*., 2017). Grazing by herbivores, including livestock, can drive and maintain this heterogeneity (Fuhlendorf *et al*., 2017), which in turn may affect how and where livestock forage (Moyo *et al*., 2011). Understanding the foraging ecology of livestock is important because it impacts both the animals themselves and their surrounding environment (Moyo *et al*., 2011).

Rangelands present grazers with a diversity of grasses and forbs which they may select to feed on to obtain sufficient nutrients (Hanley, 1982). Livestock forage selection, or lack thereof, can impact rangelands (Venter *et al*., 2019). For example, reducing livestock selectivity can lower grazing pressure and may promote plant diversity (Venter *et al*., 2019). Forage selection may change seasonally, particularly in dry seasons when plant resources become scarcer and livestock graze more opportunistically (Samuels *et al*., 2016).

Despite the importance of forage selection for cattle and rangeland management, relatively little is known about this aspect of the foraging ecology of cattle in sub-Saharan Africa (Musemwa *et al.,* 2008; Moyo *et al*., 2011). Hence, the aim of this study was to investigate the foraging ecology of Nguni cattle and Brahman cattle on two farms in KwaZulu-Natal, South Africa in the wet and dry seasons and describe the forage utilization and selection for both breeds.

Materials and Methods

Study area

This study was conducted at Wakefield and Bellwood farms in the Midlands of KwaZulu-Natal, South Africa. Both farms are situated at the foot of the Drakensburg Mountains and the source of the Umgeni River (29°29'55" S, 29°54'38" E) in the uMgungundlovu District Municipality. Mean annual rainfall is 832 mm. Mean temperatures range from 18.8°C in July to 25.2 ºC in January, when monthly rainfall is also highest (139 mm). The vegetation type for both Wakefield and Bellwood farms is “Drakensberg Foothill Moist Grassland”, which occurs on moderately rolling or mountainous terrain dominated by the grasses *Tristachya leucothrix* and *Themeda triandra* (Mucina and Rutherford, 2006). This study was carried out in the dry season (mid-June to mid-October) and the wet season (late October to late January).

Wakefield is a privately-owned, holistically managed (Savory, 1983) 592 ha farm located 1350–1780 m above sea-level, where about 130 Nguni cattle are kept. Nguni are a small- to medium-sized breed indigenous to southern Africa (Scherf, 2000) with relatively high resistance to certain diseases, high heat tolerance, and low maintenance costs (Musemwa *et al.,* 2008; Scholtz *et al*., 2008).

Bellwood is a larger farm of 1200 ha at 1460–1560 m above sea level. Bellwood keeps about 600 Brahman cattle, which are characterized by rapid maturation and a high reproductive rate (Scholtz *et al*., 2008). Bellwood uses conventional free-range management without a set grazing plan. The farm is fenced but not divided into small camps. Cattle can move freely to access preferred pasture. Bellwood is burnt annually. The Brahman cattle on Bellwood were dipped regularly, vaccinated, and provided with supplementary mineral salts and lime.

As Wakefield and Bellwood are independent working farms under different ownership, it was not possible to manipulate the management system for each breed of cattle. Although we use the same methods to describe and analyze the dietary preferences of Nguni and Brahman cattle, we make no comparisons between the two breeds because any differences we observed between them would be confounded by the management system and farm environment. Due to these limitations, we only make direct comparisons within each breed e.g., we compare the preferences of Nguni cattle in the wet season to their preferences in the dry season.

The cattle stocking rate at Wakefield was 2.2 livestock/ha units (LSU) whereas at Bellwood it was 1.2 LSU/ha. Both the Nguni and the Brahman cattle were given supplementary feed (in the form of alfalfa, *Medicago sativa*) in the dry season.

Data collection

Vegetation surveys were conducted at each location where cattle were observed foraging (see below) and then on a corresponding "random" location 50 m to the north of where the animal was foraging, for a total of two vegetation surveys per foraging location per animal. We surveyed these random points to compare the vegetation at locations where they chose to forage with another location that was available to the animal but not used (Manly *et al*., 2002). We used a distance of 50 m for the random point because it would be easily reachable for the cattle with minimal effort and could thus be considered available to the animal but still far enough to require the animal to take more than a few steps from its current location and therefore be independent from the chosen foraging point. Random points were taken north of the foraging point for consistency to facilitate efficiency in taking measurements in the field.

Vegetation surveys were conducted within 1m × 1m quadrats at both the foraging and random locations. Within each quadrat we used visual estimation to measure the percent (aerial) cover of vegetation, bare ground, forbs, shrubs, litter, and rocks. Furthermore, we recorded the dominant plant species, average height of grass, and the distance of each quadrat to the nearest tree (defined as a plant with a height > 5 m). Vegetation was sampled at a total of 2,560 locations (1,280 per farm).

To quantify plant availability for foraging cattle, the relative proportions of grass or other dominant forb and shrub species were identified in each sampled quadrat based on visual estimation of aerial cover. Grasses were categorized as "increasers", which increase in abundance when grazing pressure increases and tend to be unpalatable to livestock, or "decreasers", which decline with overgrazing (Van Oudtshoorn, 2014).

To determine dietary preferences, focal animal observations (Altmann, 1974) were performed on 32 individuals (16 Nguni and 16 Brahman) randomly selected from each farm over both the wet and dry seasons. Prior to conducting focal observations, herds were habituated to the presence of a single observer (PS). Individual cows were identified based on their unique markings, and observed animals were not separated from their herds. Focal observations were conducted on female, male, adult, and juvenile animals. All plant species eaten by the animal under observation were noted (identifications based on Van Oudtshoorn, 2014).

Each of the 32 individuals was sampled for one full day during each season (wet and dry). To avoid confounding animals' behavior with the random effect of a particular day, the sampling day for each animal was broken up into three sampling periods. Each animal was observed for one sampling period per day until it had been observed during all three time periods. The time periods were: morning (05:00 - 09:45); midday (10:00 - 14:45); and afternoon (15:00 – 19:45). This meant that a single animal would be sampled on one day in the early morning, on a different day at midday, and a third day during the late afternoon. As a corollary, on any given day, three different animals were sampled, with a different animal sampled during each of the three time periods.

Data analysis

Dietary preferences were determined for each breed of cattle based on the plant species eaten during focal sampling. We determined whether cattle demonstrated dietary preferences by testing if plants were consumed in significantly different proportions than expected based their availability (Byers *et al*., 1984). To do so, we first calculated the expected utilization of each plant species by dividing its proportion in the sampled quadrats by the total of all the plant species. We then calculated Bonferroni confidence intervals around the observed utilization of each plant using the adjustment α/n (Byers *et al*., 1984) to maintain a constant overall error in multiple comparisons.

We first used the Chi-square goodness-of-fit test to test whether there was a statistically significant difference between overall observed utilization and overall expected utilization of forage across all plant species in the wet and dry season for each breed (Byers *et al*. 1984). We then tested whether specific plant species were selected for or avoided by determining whether the observed utilization differed significantly from what would be expected based on availability. To do this, we compared the expected utilization of each plant to its Bonferroni confidence interval of observed utilization. The consumption of plants whose expected proportion of diet fell within the Bonferroni confidence interval of observed utilization did not differ significantly from what would be expected based on their availability and thus these plants were neither selected for nor avoided. Plants whose lower confidence interval was greater than the expected consumption were consumed significantly more than what would be expected based on availability and were therefore considered selected for. On the other hand, plants whose upper confidence interval of observed utilization was less than the expected consumption were consumed significantly less than what would be expected based on availability and were therefore considered avoided (Byers *et al*., 1984). All statistical analyses were carried out in the program R using functions available in base R and the "stats" package (R Core Team 2014).

Results

We recorded 17 species of grasses, two forbs, and two shrubs at Wakefield (Table 1). The most abundant grasses were *Aristida junciformis* and *Panicum ecklonii* in the dry season and *Pennisetum clandestinum* in the wet season (Table 1). At Bellwood, we recorded 18 species of grasses with *Eragrostis curvula* and *Sporobolus fimbriatus* the most abundant in the dry season and *Aristida junciformis* in the wet season (Table 1). Forbs and shrubs were rare at both farms, with a total representation <3% in quadrat surveys at either one (Table 1).

Nguni cattle were observed feeding on a total of 13 grass species and one shrub, and no forbs (Table 2). In the dry season, four grasses (*Eragrostis plana*, *Aristida junciformis*, *Panicum ecklonii* and *Pennisetum clandestinum*) accounted for 70% of all plants eaten by Nguni cattle. Supplemental feed accounted for a further 4.4%. In contrast, a single grass species (*Pennisetum clandestinum*) comprised almost half (48%) their diet in the wet season, with *Sporobolus africanus* and *Themeda triandra* together accounting for an additional 23%.

Brahman cattle fed on 13 grasses but no forbs or shrubs (Table 2). For Brahmans, the same four species of grass comprised the majority of their diet in both seasons: *Sporobolus fimbriatus, Panicum ecklonii*, *Pennisetum clandestinum*, *Themeda triandra*, accounting for 76% of their diet in the dry season and 77% in the wet season. Supplemental feed accounted for a further 23% in the dry season.

There was no significant difference between the overall observed and overall expected utilization of plants by Nguni cattle in either season (dry season: $\chi^2 = 50$, df = 40, p = 0.13; wet season: $\chi^2 = 52.6$, df = 48, p = 0.30). However, Nguni cattle demonstrated both selection and avoidance of specific plant species based on Bonferroni intervals. In the dry season, Nguni fed on three species significantly less than expected, two in proportion to their availability, and five significantly more than expected (Table 2). *Eragrostis plana* was eaten at over 63 times its proportional availability. In the wet season, five species were eaten significantly less than expected, two in proportion to their availability, and four significantly more than expected, including *Pennisetum clandestinum*, which was eaten at more than twice its expected utilization based on availability.

For Brahmans there was a significant difference between overall observed and overall expected utilization of plants in the dry season ($\chi^2 = 60$, df = 42, p = 0.04), but not the wet season ($\chi^2 = 58.7$, df = 56, p = 0.38). In the dry season, Brahmans utilized four species significantly less than expected, two species in proportion to their availability, and four species significantly more than expected (Table 2). In the wet season, six species were consumed significantly less than expected, two in proportion to their availability, and four significantly more than expected. In both seasons, *Sporobolus fimbriatus* was consumed in much greater proportion than its availability: over four times in the wet season and double in the dry season.

Table 1. Percentage cover of grasses, shrubs and forbs at Wakefield and Bellwood farms, in the dry and wet season

Plant species	**Ecological Status***	**Wakefield (% cover)**		**Bellwood (% cover)**	
		Dry season	**Wet season**	**Dry season**	**Wet season**
Grasses					
Andropogon eucomus	I	-	0.6	-	-
Aristida junciformis	I	22.7	11.5	0.8	28.8
Bromus catharticus	E	-	-	0.2	-
Cymbopogon caesius	E	0.8	6.0	5.6	1.3
Cymbopogon pospischilii	I	2.0	2.0	-	3.1
Cynodon dactylon	E	0.2	1.5	0.5	5.9
Digitaria eriantha	D	-	-	-	0.3
Elionurus muticus	I	-	0.6	-	-
Eragrostis capensis	I	2.7	-	0.2	1.8
Eragrostis curvula	I	3.0	12.0	21.0	8.8
Eragrostis plana	I	0.3	-	0.2	3.2
Harpochloa falx	E	-	-	5.9	10.0
Heteropogon contortus	I	-	0.2	-	-
Hyparrhenia hirta	E	1.7	-	-	-
Melinis nerviglumis	E	-	-	2.9	-
Monocymbium ceresiiforme	D	0.5	-	-	-
Panicum ecklonii	D	21.7	12.5	12.9	0.3
Paspalum dilatatum	E	-	-	-	0.3
Pennisetum clandestinum	E	10.3	22.1	9.2	1.3
Sporobolus africanus	I	5.8	10.3	11.8	10.0
Sporobolus fimbriatus	D	-	-	17.4	8.1
Themeda triandra	D	7.0	6.5	8.6	13.1
Tristachya leucothrix	I	18.4	13.1	-	0.3
Shrubs					
Pteridium aquilinum		0.3	0.6	1.4	0.3
Rubus cuneifolius		2.2	0.3	-	-
Rubus fruticosus		-	-	0.2	-
Forbs					
Berkheya setifera		0.3	-	-	0.3
Helichrysum setifera		0.2	-	-	0.3

* The ecological status of grass species is from Van Oudtshoorn (2014).
Where: I = increaser species, D= decrease species, and E= exotic and/or invasive species.

Table 2. The observed utilization of the most abundant plant species fed on by Nguni and Brahman cattle in the wet and dry seasons

Cattle Breed	Season	Plant species	Expected	Observed#	Lower – upper intervals
Nguni	Wet	*Pennisetum clandestinum*	0.22	0.48 (+)	0.44 – 0.52
		Tristachya leucothrix	0.13	0.00 (–)	0.00 – 0.01
		Aristida junciformis	0.12	0.08 (–)	0.06 – 0.10
		Panicum ecklonii	0.12	0.09 (–)	0.06 – 0.11
		Eragrostis curvula	0.12	0.00 (–)	0.00 – 0.01
		Sporobolus africanus	0.10	0.13	0.10 – 0.15
		Eragrostis plana	0.06	0.00 (–)	0.00 – 0.01
		Themeda triandra	0.06	0.10 (+)	0.08 – 0.12
		Cynodon dactylon	0.015	0.05 (+)	0.03 – 0.06
		Heteropogon contortus	0.002	0.01	0.002 – 0.016
		*Rubus cuneifolius**	0.002	0.02 (+)	0.01 – 0.03
	Dry	*Aristida junciformis*	0.23	0.19 (–)	0.16 – 0.20
		Panicum ecklonii	0.22	0.16 (–)	0.14 – 0.18
		Pennisetum clandestinum	0.10	0.16 (+)	0.14 – 0.18
		Sporobolus africanus	0.06	0.07	0.06 – 0.09
		Eragrostis curvula	0.04	0.02 (–)	0.02 – 0.03
		Eragrostis capensis	0.03	0.03	0.02 – 0.05
		Cymbopogon pospischilii	0.02	0.04 (+)	0.03 – 0.06
		Rubus cuneifolius	0.02	0.04 (+)	0.03 – 0.05
		Panicum natalense	0.01	0.04 (+)	0.03 – 0.05
		Eragrostis plana	0.003	0.19 (+)	0.17 – 0.23
Brahman	Wet	*Aristida junciformis*	0.30	0.00 (–)	0.00 – 0.01
		Themeda triandra	0.14	0.12	0.09 - 0.14
		Eragrostis curvula	0.10	0.07 (–)	0.05 - 0.09
		Sporobolus africanus	0.10	0.04 (–)	0.03 - 0.05
		Sporobolus fimbriatus	0.08	0.35 (+)	0.31 - 0.40
		Cynodon dactylon	0.06	0.01 (–)	0.005 – 0.02
		Cymbopogon pospischilii	0.03	0.03	0.01 – 0.04
		Eragrostis plana	0.03	0.01 (–)	0.00 – 0.02
		Eragrostis capensis	0.02	0.01 (–)	0.00 – 0.01
		Pennisetum clandestinum	0.01	0.12 (+)	0.10 - 0.15
		Panicum ecklonii	0.003	0.18 (+)	0.15 - 0.21
	Dry	*Eragrostis curvula*	0.21	0.11 (–)	0.08 - 0.14
		Sporobolus fimbriatus	0.17	0.35 (+)	0.31 - 0.40
		Panicum ecklonii	0.13	0.17 (+)	0.15 - 0.21
		Sporobolus africanus	0.12	0.07 (–)	0.05 - 0.09
		Pennisetum clandestinum	0.09	0.12 (+)	0.10 - 0.15
		Themeda triandra	0.09	0.12	0.09 - 0.14
		Cymbopogon caesius	0.06	0.00 (–)	0.00 - 0.01
		Harpochloa falx	0.06	0.00 (–)	0.00 - 0.01
		Aristida junciformis	0.01	0.00	0.00 - 0.01
		Cymbopogon pospischilii	0.00	0.03 (+)	0.01 - 0.04

(–) indicates plants eaten significantly less than expected.
(+) indicates plants eaten significantly more than expected.
No symbol after the observed value indicates plants eaten in proportion to availability.
**Rubus cuneifolius* is a shrub species.

Discussion

Although we are unable to directly compare Nguni and Brahman cattle due to differences between management systems, we found that within each breed, dietary utilization and selectivity varied between the wet and dry seasons and strong preferences for certain plant species existed. In the dry season, Nguni selected strongly for *Eragrostis plana*. This plant has low palatability and crude protein levels (Carvalho and Batello *et al*., 2009) and is generally not preferred forage (Bremm *et al.*, 2012). Previous studies have shown that increasing *E. plana* limits cattle's access to more preferred forage, increases search costs, and forces livestock to reduce their selectivity to maintain foraging intake (Bremm *et al*., 2012). It is unclear why Nguni show such a strong preference for *E. plana* at Wakefield. Further research could clarify this behavior and investigate how this may affect their production.

Brahman cattle selected high value grass species, particularly *Sporobolus fimbriatus*, *Panicum ecklonii*, *Pennisetum clandestinum*, and *Themeda triandra* (Van Oudtshoorn, 2014), which they continued to utilize in nearly the same proportions in the dry season as the wet season, even though they were not as widely available. Because the Brahmans were conventionally managed, they were free to seek out and select plants even when they became scarcer. From our results, it is unclear how this behavior might change under a different management system and this requires further research.

In addition to grass, cattle also consume leaves of trees and bushes, both invasive aliens such as *Psidium guajava* and indigenous trees such as *Terminalia sericea* and *Philenoptera nelsii* (Mpanza *et al*., 2009). We found that Nguni cattle switched to browsing on *Rubus cuneifolius* during the dry season when a shortage of palatable grass species was observed. Nguni cattle in Namibia have also been observed switching to browse, particularly in the dry season (Radloff *et al*., 2013). This switch to browse may point to their ability to respond to the spatial and temporal availability of resources (Radloff *et al*., 2013).

Conclusion

We report, for the first time, the dietary preferences of Nguni cattle under holistic management. We show that Nguni cattle are flexible in their diet and can switch to browsing at times of food shortage, notably in the dry season. In addition, we present the dietary preferences of Brahman cattle under conventional free-range management. However, because we only studied one herd of each cattle breed and each herd was managed differently on separate farms, we cannot directly compare either the effects of breed or management on the foraging ecology of cattle in the region. Nevertheless, our results suggest that due to their greater flexibility in diet and reduced reliance on supplementary feed, Nguni cattle may be particularly well-suited to this heterogeneous landscape with a marked dry season when resources are scarce.

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