



International Journal of Veterinary Sciences and Animal Husbandry



ISSN: 2456-2912

NAAS Rating (2026): 4.61

VET 2026; 11(8): 216-222

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www.veterinarypaper.com

Received: 14-05-2026

Accepted: 18-06-2026

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Seasonal variations in activity pattern and performance of sheep and goats in the semi-arid rangelands of Kenya

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DOI: <https://www.doi.org/10.22271/veterinary.2026.v11.i8d.3742>

Abstract

Information on seasonal forage intake, activity patterns and performance of grazing ruminants is important for the design of sustainable management of rangeland resources. An assessment was conducted to quantify sheep and goats forage intake, performance and their time partitioning to different activities in a typical grazing day during dry and rainy seasons in semiarid rangelands of Kenya. Six adult female animals of Red Maasai, Dorper, and Galla breeds aged 2–3 years were intermittently observed at 5-minute intervals. Using direct observation, their behaviors and forage intake were recorded from the time they were released from their overnight enclosure to graze in the field (0830h) until they returned to their enclosure (1600h). During this period of approximately 7.5 hours, activity patterns in feeding, standing, drinking water, moving, lying, and other behaviors were recorded per each 5-minute time interval. The average forage intake, daily live weight gain (LWG) was calculated. Data were subjected to analysis of variance using general linear model, fitting initial live weight as a covariant and means separated using least significant difference. Subsequently, the percentage of each activity was calculated from the total number of observations (n=540) recorded during each season. Statistical test for seasonal difference on intake and time spent on different activities were determined using mixed model of SAS (2002) where seasons (S) and breed (B), were independent variables, affecting forage intake and time spent in different activities. In both seasons, all breeds were found to spend more than 80% of their time eating. Breed effects were observed ($p < 0.001$) in partitioning feeding behavior, grazing on grasses and herbs, and browsing on shrubs and tree forages. In both seasons, Galla goats partitioned 61.1% of time to browsing, whereas Dorper and Red Maasai spent 10.8 and 6.2%, respectively, to the same activity. On the other hand, in both seasons, Dorper and Red Maasai sheep were found to spend more time grazing 79.2 and 81.1, respectively, while Galla goats spent 32.5 of their overall eating time. Seasonal effects were observed ($p < 0.05$) on both dry matter intake and LWG. The rainy season had a higher mean intake and LWG than dry season ($p < 0.0001$). It is concluded that as a compensatory adaptation mechanism, both sheep and goats tend to modify their behavior to adapt to seasonal changes in plant availability and ambient temperatures to meet nutritional requirement for both maintenance and production, making them suitable in areas with limited forage availability and variable climatic conditions.

Keywords: Browsing, grazing time, feeding behaviour, time partitioning, small ruminants

1. Introduction

Pastoralism is the main farming activity in the semi-arid rangelands of Kenya (Wasonga *et al.*, 2010) ^[1] where more than 50% of total sheep and goats are kept as these species are highly adaptable to harsh environmental conditions (Nyariki & Amwata 2019) ^[2]. However, in recent years the semi-arid rangelands are faced with climate change, land degradation, vegetation loss, and overgrazing (Mganga *et al.*, 2015) ^[3], which have implications on sustainable rangeland systems and ruminant production. Goats are classified as browsers and sheep as grazers (Hofmann, 1989) ^[4]. Forage availability, chemical composition of available plant species and climate change tend to affect sheep and goats feeding activity pattern, forage intake and subsequently their performance (Castro & Fernandez, 2016; Safari *et al.*, 2011; Schlecht *et al.*, 2006) ^[5, 6, 7]. It is well known that increased temperatures accelerate the rate of

of plant maturity in the semi-arid rangelands, leading to increased fraction of cell wall constituents and hence poor forage quality (Krämer *et al.*, 2012; Moore *et al.*, 2020) [8, 9]. Sampaio *et al.*, (2010) [10] reported that rangeland forages have high cell wall contents and low crude protein (CP) levels during the dry season, limiting animal intake and performance, whereas during the rainy season, CP levels are higher and cell wall constituents are lower, favoring feed intake and, as a result, animals perform better. Studies (Schroeder *et al.*, 2019; Samuels *et al.*, 2016; Egea *et al.*, 2014) [11, 12, 13] have found that sheep are able to browse in grazing areas with low presence of herbage; whereas goats are found to graze in areas with scarce browse species. These indicating feeding adaptation strategy by livestock to seasonal variations on plant species availability.

Sheep and goats time partitioning to feeding and other non-feeding activities (resting, ruminating, grooming, etc.) are found to differ between seasons (Castro & Fernandez, 2016) [5]. The performance of livestock in the semi-arid rangelands is a function of feed intake, forage quality and other factors. Feed intake is directly associated with time partitioning to feeding activity (O'Reagain, 2021; Edouard *et al.*, 2010) [14, 15].

In the semi-arid rangelands of Kenya, Leparmarai *et al.*, (2018) [16] investigated time partitioning of cattle and camels to different activities and found these two species partitioning more than 80% of their daytime in the field to eating (grazing and browsing). On the contrary, there is no information available for seasonal forage intake, time partitioning to eating and performance of sheep and goats under pastoralism. Knowledge on seasonal effect on activity pattern, forage intake and performance in the semi-arid rangelands is important for the design of sustainable rangeland management. The aim of this study was to assess the seasonal variation in activity pattern, forage intake and live-weight gain (LWG) of sheep (Dorper and Red Maasai) and Galla goats foraging on a grassland habitat in the semi-arid rangeland of Machakos County, Kenya.

2. Materials and Methods

2.1 Statement of animal rights

The materials and methods of the study were approved by The Institutional Animal Care and Use Committee (IACUC) at the International Livestock Research Institute (ILRI) and the National Commission of Science and Technology of Kenya under License Number NACOSTI/P/22/17112.

2.2 Study site

This study was conducted in the semi-arid rangeland of Kapiti Research Station & Wildlife Conservancy of the International Livestock Research Institute (ILRI), located at Machakos County, Kenya. The area location is 37°08'00.68" E: 1°37'18.15" S, at an elevation of 1650–1900m, receiving an annual average rainfall of 550mm (ILRI, 2017) [17]. This study was carried out at end of both a dry season (September–October 2020) and rainy season (November–December 2020). Small ruminant animals in the ranch included 1200 sheep (Red Maasai, Dorper and their crossbreeds) and 250 Galla goats (ILRI 2017) [17]. The animals spend the night confined in corrals to prevent attack by predators and theft.

2.3 Experimental animals

The experiment involved six female animals from each of the Dorper and Red Maasai sheep breeds, as well as Galla goats, hereafter referred to as breeds. During each season, the

animals were adult females aged 2–3yrs old, non-lactating, and non-pregnant, with weights averaging 53.2±1.8 kg for Dorper, 37.4±4.7 kg for Red Maasai, and 42.3±2.6 kg for Galla. All experimental animals, both sheep and goats, were managed as a single group integrated into a larger flock consisting of 88 animals (44 sheep and 44 goats). They were observed to be healthy and in good condition.

2.4 Measurement of seasonal forage intake of sheep and goats

The grazing behaviour observation was carried out by a team of two people. One of them was dedicated to observation of the particular animal general and biting activities, while another person assisted with the operation of the stopwatch and sample labelling. The team members were trained on general activity determination (grazing, resting, ruminating, etc.), bite categorization, and bite size determination, of sheep and goats within a flock. The team was familiarized with the flock over a five-day period by being closer to the animals (Bonnet *et al.*, 2015) [18]. This familiarization enabled the observers stay at around 2 m of distance from the observed animal (Leparmarai *et al.*, 2018; Marquardt *et al.*, 2010) [16, 19]. The animals were observed for their grazing behaviour during the grazing period practiced at the farm (8:30am to 4:00 pm). Grazing behaviour was observed over 18 days. Only once, a single animal was randomly selected and monitored per day while alternating with respect to the breed and species. Forage biting (foraging) was monitored intermittently (during 1 min, every 5 min) and categorized into three bite sizes: small bite (a few leaves/flowers or small parts of leaves per bite), half bite (a cluster of leaves and small stem per bite), and full bite (sizable portion of leaves, or leaves and stems per bite) as per Leparmarai *et al.*, (2018) [16] and Agreil & Meuret (2004) [20]. Rate of biting (bites/min) was counted once bite size was categorized (Leparmarai *et al.*, 2018; Agreil & Meuret, 2004) [16, 20].

When an animal encountered a patch of herbage, bite sizes were recorded as full, medium or small bites. Forage samples of the most selected plant species were collected by simulating the bite with a gloved hand and a knife in triplicate for each bite size. A mixed bite category (mixed plants species within a bite) was used for the less selected plant species, based on similarities in morphological characteristics (Leparmarai *et al.*, 2018) [16]. Samples, at collection, were immediately put into paper bags and later air-dried until constant weight. After collection, samples were oven-dried for 12 hours at 105°C and the data used to estimate various plant species contributions and total forage intake for the observation period (5-min intervals and n=90).

2.5 Measurement of seasonal activity pattern of sheep and goats

This data was extrapolated from the measurement of forage intake. Where, at each observation time the specific animal activity was recorded. Recorded activity categories included: drinking water, eating (browsing or grazing), grooming, panting, standing, ruminating and lying, running and walking (in search of forage or either coming back to or leaving corrals). The daily daylight (7 and ½ h) partitioning of time devoted to each activity was calculated by adding the categories observed at the 5-min intervals and then expressed as a percentage of the total number of observations (n=90).

2.6 Statistical analysis

Statistical test for seasonal difference in time spent on

ingestion, standing, moving, lying and any other behavior was determined using mixed model of SAS (2002) where seasons (S), breed and interactions were independent variables affecting time spent in different activities. Means separation was conducted using Least Significant Difference (LSD) test at 0.05 level of significance. Means were considered statistically different from each other when $p < 0.05$. The statistical model is described below:

$$Y_{ijk} = \mu + A_i + B_j + AB_{ij} + \varepsilon_{ijk}$$

where, Y_{ijk} = Overall observation; μ = Overall mean; A_i = fixed effect due to i th seasons (Dry and rainy season); B_j = fixed effect due to j th breed or animal type; AB = Interaction effect of i th season and j th breed; ε_{ijk} = random error
Live weight data was analyzed using SAS (2002). Initial live

weight was fitted as covariant to correct for unexplained variations in treatment means during mean comparisons. Means separation was conducted using least significant difference (LSD) test at 0.05 level of significance means were considered different if $p < 0.05$.

3. Results

From Table 1, shows that all breeds, in both seasons, spent a larger portion of their diurnal time (90.2–91.2%) on feeding (grazing and browsing), then on walking without marked season effects ($p > 0.05$) on the partitioning of time to the measured activities. An exception to this was during the dry season, when a larger time proportion was devoted to water drinking ($p < 0.0001$) than during the rainy season (0.8 vs. 0.1%). In the dry season, Dorper were found to partition some running (mainly running in search of water).

Table 1: Effect of season (S; dry and rainy) on diurnal (0830–1600 h) time partitioning (% of total time) of their activities when free ranging in a semi-natural rangeland at Kapiti Research Station and Wildlife Conservancy

Activity	Dry season		Rainy season		P Values	
	Mean	SEM	Mean	SEM	Dry	Rainy
Drinking water	0.8	0.2	0.1	0.2	<.0001	0.4472
Eating	90.2	1.2	91.2	1.2	<.0001	<.0001
Browsing	24.9	1.8	27.2	1.8	<.0001	<.0001
Grazing	64.4	2.2	64	2.2	<.0001	<.0001
Grooming	0.2	0.9	0.1	0.9	0.0497	0.1893
Panting	0.4	0.1	0.1	0.1	0.0227	0.4794
Ruminating	0.2	0.2	0.6	0.2	0.143	0.0019
Running	0.1	0.1	—	—	0.3332	—
Standing	2.3	0.7	2.9	0.7	0.0027	0.0002
Lying	0.6	0.2	0.3	0.2	0.0066	0.195
Walking	6	0.7	4.7	0.7	<.0001	<.0001
Total	100		100			

From Table 2, Breed differences were observed ($p < 0.001$) in time partitioned to eating, with Galla goat breed spending more time than the sheep breeds (Dorper and red Massai), which was even greater when activity was categorized into grazing and browsing ($p < 0.001$). However, no breed differences were observed ($p > 0.05$) in time partitioned to water drinking, grooming, ruminating, running, lying or walking. This suggest that, independent of seasons, sheep (Red Maasai and Dorper ewes) were comparable in activity behavior, partitioning their time to grazing or browsing, but differing in allocating more time ($p < 0.001$) to grazing and less time ($p < 0.001$) to browsing times than goats. In both seasons, larger percentage of time among Dorper (79.2) and among Red Maasai sheep (81.1%) was spent grazing (i.e.,

eating grasses and herbs) than did the Galla goats (32.5%). All breeds spent more time drinking water during the dry season than during the rainy season (0.8% vs. 0.1%). Breed had a significant effect on the time spent standing ($p < 0.05$), with Red Maasai partitioning much more of their time to this activity compared to Dorper sheep and Galla goats. Panting also showed season variation, with Red Maasai sheep spending more time panting than the Dorper sheep or Galla goats. Lying and ruminating time were comparable ($p > 0.05$) between the season or breeds or their interactions, an observation also true for time partitioned to grooming, walking (walking without eating and also walking from corrals and back) and running.

Table 2: Effect of animal breed (B; Dorper, Red Massai and Galla) on diurnal (0830–1600 h) time partitioning (% of total time) of their activities when free ranging in a semi-natural rangeland at Kapiti Research Station and Wildlife Conservancy

Activity	Means			SEM			P Values		
	Red Maasai	Dorper	Galla	Red Massai	Dorper	Galla	Red Maasai	Dorper	Galla
Drinking water	0.7	0.4	0.4	2.0	2.0	2.0	0.006	0.0753	0.0673
Eating	88.8 ^b	89.6 ^b	93.6 ^a	1.5	1.4	1.4	<.0001	<.0001	<.0001
Browsing	6.2 ^b	10.8 ^b	61.1 ^a	2.2	2.2	2.2	0.008	<.0001	<.0001
Grazing	81.1 ^a	79.2 ^a	32.5 ^b	2.7	2.7	2.7	<.0001	<.0001	<.0001
Grooming	0.2	0.0	0.3	0.1	0.1	0.1	0.1168	1.0	0.0166
Panting	0.7 ^a	0.1 ^b	0.0 ^b	0.2	0.2	0.2	0.0019	0.6808	1.0
Ruminating	0.5	0.6	0.2	0.2	0.2	0.2	0.0273	0.0088	0.3821
Running	0.0	0.4	0.0	0.2	0.2	0.2	1.0	0.1038	1.0
Standing	3.9 ^a	3.4 ^a	0.6 ^b	0.9	0.9	0.9	<.0001	0.0005	0.519
Lying	0.5	0.2	0.5	0.2	0.2	0.2	0.0241	0.4297	0.0525
Walking	6.2	5.3	4.5	0.9	0.9	0.9	<.0001	<.0001	<.0001
Total	100	100	100						

^{a, b} means followed by different letter superscripts differ ($p < 0.05$)

Seasonal average feed intake and live weight gain of sheep breeds (Dorper and Red Maasai) and Galla goats in a dry and rainy seasons

In both dry and rainy seasons, the average initial LW, final LW, LWG, and intake along with the corresponding standard deviation, are shown in Table 3 for the Dorper and Red

Maasai sheep breeds and the Galla goat breed. Breed x season interactions had no effect on initial LW, final LW, or LWG however, a significant effect was found on intake ($P = 0.0041$). Seasons had a significant impact on LWG, final LW and intake ($p < 0.05$), but initial and final LW varied significantly across breeds (Table 3).

Table 3: Initial and final live weight (LW, kg/head), average daily LW change (LWG g/day) and (intake g/90 minutes) of Dorper and Red Maasai ewes and Galla does during the dry and rainy seasons

Item (kg/g)	Dry season			Rainy season		
	Dorper	Red Maasai	Galla	Dorper	Red Maasai	Galla
Initial	53.2±1.9	42.3±2.7	37.4±5.0	53.2±5.1	43.7±2.6	38.6±5.0
Final	53.0±2.3	42.2±3.0	37.1±3.8	55.8. ±5.8	46.7. ±3.0	41.2.0±5.0
LWG	-8.3±139.3	-8.3±34.1	-15.8±98.8	129.2±45.9	150.0±80.6	129.2±45.9
Intake	61.0±8.1 ^b	44.6±8.9 ^c	58.7±12.9 ^b	102.3±12.2 ^a	107.1±14.2 ^a	88.5±8.9 ^{ab}

a, b, c means in a row followed by different letter superscripts differ ($p < 0.05$), LWG = Live weight change (g/day); IW= initial weight (kg); FW=final weight (kg); intake g/90 minutes

Table 4 shows significant differences in initial and final LW between the Dorper, Red Maasai, and Galla breeds ($p < 0.0001$). Dorper had the highest average initial and final LW, followed by Red Maasai and Galla. Furthermore, there were seasonal variations in intake and live weight gain (LWG). The Rainy season had a significantly higher mean intake and

LWG than the Dry season ($p < 0.0001$), suggesting better conditions favoring intake and subsequent weight gain during this period. In contrast, LWG in the Dry season shows no significant deviation from zero, indicating that weight gain is minimal during this time ($P = 0.6$).

Table 4: Average Initial and Final (LW, kg/head) for Dorper, Galla, and Red Maasai Sheep (Averaged Over Two Seasons) and Average daily LW change (LWG g/day), final LW and intake for all breeds in a Dry and Rainy Seasons

Season	LWG			Final LW			Intake		
	Mean	SEM	P value	Mean	SEM	P value	Mean	SEM	P value
Rainy	138.4a	23.0	<.0001	47.9a	0.92	<.0001	99.3 ^a		<.0001
Dry	-13.1b	23.0	0.6	44.1b	0.92	<.0001	54.8 ^b		<.0001
Breeds	Initial LW			Final LW					
	Mean	SEM	P value	Mean	SEM	P value			
Dorper	53.2 ^a	1.10	<.0001	54.4 ^a	1.23	<.0001			
Red Maasai	43.0 ^b	1.10	<.0001	44.4 ^b	1.23	<.0001			
Galla	38.0 ^c	1.10	<.0001	39.1 ^c	1.23	<.0001			

a, b, c Mean values with different letter superscripts are significantly different ($p < 0.05$). LWC = Live weight change (g/day); IW= initial weight (kg); FW=final weight (kg); intake g/90 minutes

From figure 1, the regression model explained 46% of the variation in weight change ($R^2 = 0.46$, $P = 0.019$). Season had a significant effect on weight change ($p < 0.01$), with animals in the rainy season gaining more weight than those in the dry season, in contrast, intake was not a significant predictor of

weight change ($P = 0.39$) and its interaction was not significant. This indicates that seasonal conditions, rather than the level of feed intake, were the main drivers of weight change in the study.

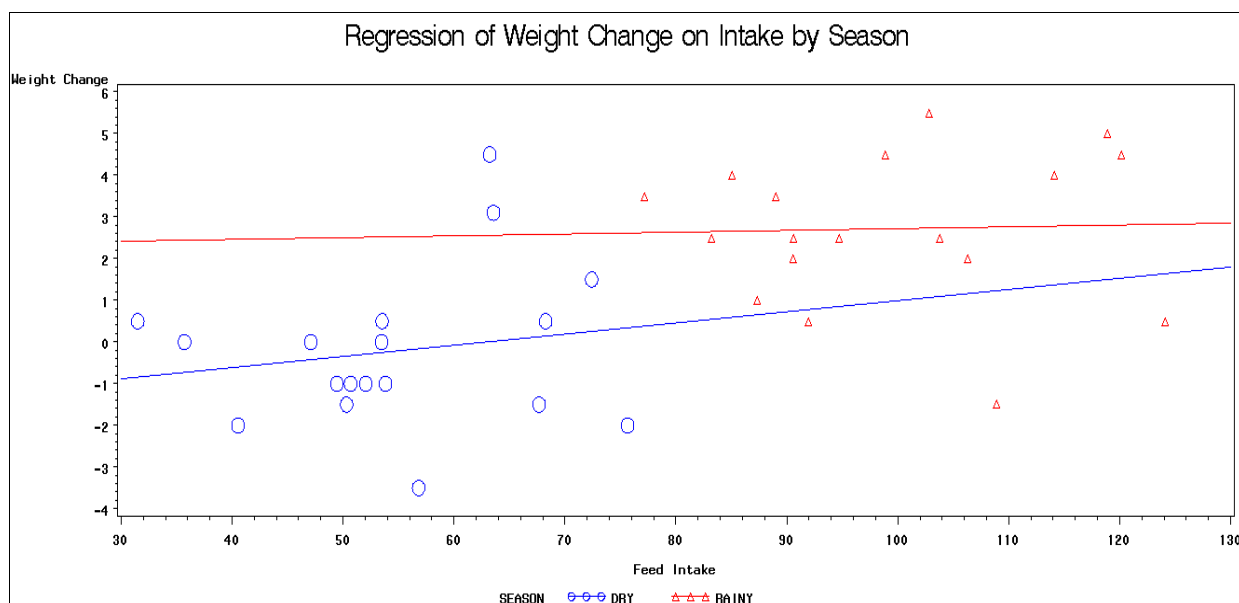


Fig 1: Relationship between weight changes and forage intake in a dry and rainy season

4. Discussion

All breeds and seasons spent more than 80% of their time eating. This observation concurs with other studies in which sheep and goats were found to spend most of their daytime eating with a grazing time allowance of 5 to 9 hours (Kam *et al.*, 2020; Kam & Degen, 2012) ^[21, 22]; Safari *et al.*, 2011) ^[6]. The latter is a consequence of husbandry practice of enclosing animals in corrals for more than two-thirds of their daily time without access to feed or water. Similar behaviors have been observed in cattle and camels (Leparmarai *et al.*, 2018) ^[16]. During the experiment at Kapiti Research Ranch Station and Wildlife Conservancy, grazing was planned to match stocking capacity. This grazing strategy takes into account seasonal changes and new forage data, to rehabilitate severely degraded grassland ecosystems affected by bush encroachment, particularly by unpalatable shrubs such as *Acacia drepanolobium*, *Solanum incanum*, and *Aspilia* spp (Sircely *et al.*, 2020) ^[23]. Thus, in situations where allowance for grazing is severely limited and/or forage availability and quality are reduced, animals prioritize their time to eating activity in order to maintain forage intake (Miguel *et al.*, 2014) ^[24].

In both dry and rainy seasons, Galla goats spent most of their time browsing (eating shrubs and trees), which is what other studies have reported with goats when free ranging in areas with readily available browse species (Schroeder *et al.*, 2019; Yayneshet *et al.*, 2008) ^[11, 25]. On the other hand, Dorper and Red Maasai sheep were found to spend more time grazing (eating grasses and herbs). Kam & Degen, (2012) ^[22] investigated the foraging behavior of sheep and goats in Israel and found that where plant species is diverse sheep tend to prefer grasses and herbs (grazing) while goats prefer shrubs and trees (browsing). Ferreira *et al.*, (2013) ^[26] investigated the foraging behavior of sheep and goats in improved pasture rangelands and found that sheep are primarily grazers switching to browsing only when forage availability is limiting, whereas goats are primarily browsers switching to grazing only when forage availability is limited. Mohammed *et al.*, (2020) ^[27] studied grazing behavior of co-grazing sheep, goats, cattle, and camels in Ethiopian pastoral and agro pastoral areas. Their observations were that sheep and cattle spend more than half of their time grazing while goats and camels spend a similar amount of time browsing. In general, the grazing habits of sheep and goats were different in this study because the sheep were observed to wander in groups, eating numerous bites at one area before slowly moving on to the next, whereas the goats browsed individually, spending less time on a single plant before rapidly moving on to the next.

Both sheep and goat breeds were found to spend more time drinking water in the dry season than in the rainy season, which is an observation consistent with those of other studies (Safari *et al.*, 2011) ^[6]. The more water intake during the dry season can be attributed to a higher ambient temperature during the dry season. Ruminating is an important activity for reduction of particle size enabling digestion. In this study, this behavior did not change with seasons or with breeds and was in overall less than one percent of the diurnal activity.

Marcone *et al.* (2021) ^[28] suggested that reduced rumination time in ruminants is associated with heat stress. In the present study, however, the relatively short rumination time may not be attributed to heat stress alone. The animals were allowed to free-range for only a limited period each day, which may have encouraged them to prioritize forage intake over rumination. Consequently, rumination was likely postponed to subsequent

resting periods after grazing. Similar behavioral adaptations have been reported in grazing ruminants, where restricted grazing time reduced rumination during grazing but increased rumination during later resting periods, enabling animals to maximize forage intake (Gregorini *et al.*, 2012) ^[29]. This behavioral pattern is consistent with the natural feeding strategy of ruminants, in which grazing is typically followed by rumination during periods of rest, particularly at night (Sun *et al.*, 2023) ^[30]. It is established that rumination time is strongly related to fiber intake, particularly NDF intake, with forages containing more than 65% NDF classified as low-quality (Elgersma & Søgaard, 2018) ^[31]. According to Van Soest (1994) ^[32], increased NDF promotes increased rumination time due to the increased need for fiber digestion. Nevertheless, the lack of significant differences in rumination time across seasons and breeds could be attributed to not achieving voluntary feed intake able to trigger clearance of large particles from the rumen throughout rumination. All breeds spent a portion of their day standing mostly in the shade, with sheep breeds (Dorper and red Maasai) spending more time doing so than goat breeds (Galla)

Seasons had an effect on both intake and the performance of sheep (Dorper and Red Maasai) and Galla goats. This could be attributed to seasonal influence on forage availability and quality. For example, Mburu, (2015) ^[33] reported that forage availability in the coastal semi-arid rangelands of Kenya was higher and of better quality in the rainy season than in the dry season. In turn, Safari *et al.*, (2011) ^[6], based on studies carried out in semi-arid rangelands of Tanzania, reported higher quality forages during the rainy season compared to dry season. It is also well known that increased temperatures accelerate the rate of plant maturity in the semi-arid rangelands, leading to increased fraction of cell wall constituents and hence poor forage quality (Krämer *et al.*, 2012; Moore *et al.*, 2020) ^[8, 9]. Sampaio *et al.*, (2010) ^[10] reported that rangeland forages have high cell wall contents and low crude protein (CP) levels during the dry season, limiting animal intake and performance, whereas during the rainy season, CP levels are higher and cell wall constituents are lower, favoring feed intake and, as a result, animals perform better.

The findings of this study provide important information for the sustainable management of semi-arid rangelands and the improvement of small ruminant production systems. The differences in forage selection among Galla goats, Dorper sheep, and Red Maasai sheep suggest that these breeds use rangeland vegetation differently. Therefore, grazing these species together can improve the utilization of grasses, shrubs, and browse species. This complementary use of forage resources can reduce grazing pressure on individual plant species. Consequently, mixed-species grazing can help maintain plant species diversity and overall sustainable utilization of the rangelands. Furthermore, due to increased heat stress, both sheep and goat breeds require adequate water availability during the dry season. High-quality forage provision or supplementation is critical for maximizing rumination and nutrient utilization while species-specific behaviors such as standing times should inform grazing management strategies. Integrating these insights into rangeland management improves animal welfare and productivity under different rangeland environmental conditions.

5. Conclusion

To meet their nutritional requirements, both sheep and goats

partition almost all their time to eating whereas goats mostly partition time to browsing and sheep mostly to grazing. Both sheep and goats spend more time drinking water during the dry season than during the rainy season, likely as a response to higher temperatures and the high dry matter content of their diets. Seasons has an effect on both intake and performance of sheep (Dorper and Red Maasai) and Galla goats. Both sheep and goats had a higher intake and performed better in the rainy season than the dry season. With climate change, knowledge and regular assessments of how sheep and goats respond to seasonal temperature increases and the amount of dry matter in their dietary preferences are critical because they guide decisions about rangeland sustainability, water provision, overnight housing, and grazing management. By considering these factors, farmers and ranchers can improve the adaptability of their livestock systems and mitigate the negative effects of changing climate conditions.

6. Acknowledgement

The authors would like to thank the International Livestock Research Institute (ILRI) Mazingira Centre and the African Center of Excellence in Sustainable Agriculture and Agribusiness Management (CESAAM) for sponsoring this research. We would also like to thank the ILRI Kapiti Research Station for their assistance in organizing and facilitating the field data collection

7. Author contribution

This study was conducted collaboratively by all authors. Hannah Wairimu Mwaura, James Ombiro Ondiek, Daniel Girma Mulat, and Bockline Omedo Bebe contributed to the conceptualization and design of the study. Hannah Wairimu Mwaura conducted the data collection. Data analysis, manuscript writing, proofreading, and preparation of the manuscript for publication were handled by Hannah Wairimu Mwaura, James Ombiro Ondiek, Daniel Girma Mulat, and Bockline Omedo Bebe

8. Conflict of Interest

The authors state that they have no conflicts of interest

Financial Support

Not available

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How to Cite This Article

Mwaura HW, Ondiek JO, Mulat DG, Bebe BO. Seasonal variations in activity pattern and performance of sheep and goats in the semi-arid rangelands of Kenya. *International Journal of Veterinary Sciences and Animal Husbandry*. 2026;11(8):216-222