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SEASONAL GROWTH AND GRAZING BEHAVIOUR OF DJALLONKÉ SHEEP RAISED IN ECOSYSTEMS OF IRRIGATED AND RAIN FED LANDSCAPES OF THE GUINEA SAVANNA ZONE OF GHANA

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Abstract
The study was conducted in the Nabdam, Bawku-West, Kasena-Nankana districts of the Upper East Region, and the Kumbungu district in the Northern Region of Ghana. Twelve (12) ecosystems within four landscapes were selected for this research in the rainy (May- October) and dry (November-April) seasons. Twelve (12) grazing sites were purposively selected and a two-step sampling approach was used in the selection of sampling points within the grazing lands. The grazing behaviour of 36 Djallonké rams (weighing ≈13kg) was observed in the 12 ecosystems. Generally, Feeding, Watering and Walking by the rams were affected by the season in both landscapes. The rams spent less time for watering (11% dry season vs, 8 % wet season) and walking (40% dry season vs. 30% wet season) but high percentage of time on feeding (45% wet season vs. 31% dry season) during the wet season in the rain-fed landscape. Forage analysis were carried out to determine the effect of ecosystem and season on the growth performance of the rams in the landscapes. Season had a significant effect on all the growth parameters. Higher final weight (16.56 vs 15.08 kg), final weight gain (3.27 vs 2.28 kg) and average daily weight gain (54.5 vs 38.1 g) was observed in the wet season than in the dry season in the irrigated landscape. In the rain fed landscape, the effects of the ecosystem and season interaction was not significant, there was however a significant effect of season on the growth parameters. Higher final weight gain (2.8 vs 2.3 kg) and average daily weight gain (46.9 vs 39.4 g) was recorded in the wet season than in the dry season in the rain-fed landscape for the rams. The two-way interaction effect of ecosystem and season was not significant for any of the nutritional parameters in the irrigated landscapes. With the exception of dry matter (DM) which recorded higher values in the dry season, the main effect of season was significant with the wet season recording higher crude protein (CP) than the dry season in both rain fed and irrigated landscape.

Keywords: Seasons, Growth, Behaviour, Djallonké Rams, Irrigated, Rain-fed

Introduction

Small ruminants play a very important role in the food security and economy of most households in Africa. They are a major source of animal protein and income (Abebe, 2012). Small ruminants' production does not only provide essential animal products, it also serves as employment for millions of urban and rural people (Asnakew, 2005). The nutrition of these animals is usually derived from heterogeneous unimproved natural pasture across most ecosystems. The quality and quantity of biomass from the ecosystems often fluctuates with changes in season being the most significant factor (Nyamekye, 2010). Different landscapes may offer different ecosystem services. The rain-fed landscape is the most exploited landscape in the Savana Agro-ecological zone. It provides a major ecosystem service in the form of provisioning services which comprise of food, freshwater, fuelwood, fiber, biochemical, thatch for roofing animal pen, fodder, medicinal plants and genetic resources (MA, 2005; Havstad *et al.* 2007; Sala *et al.* 2017). Plants and animals form part of the ecosystem on which mankind relies for their needs. There is, however,

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not much understanding with regards to the interaction between plants and animals within the ecosystem (Akapali, 2018). This lack of proper understanding of interactions between plants and animals in the field has hindered the maximum use and benefits of grazing lands.

Animals mostly walk long distances in search of good pasture which may or may not be available. This problem even becomes more worrying during the dry season when most of the fields are burnt leaving bare ground (Akapali *et al.,* 2018). There is even a bigger problem in the rainy season where crop farmers in an attempt to protect their crops, deny their animals access to natural forage by tethering them, hence reducing the animal's access to good grazing material. Decisions concerning interventions and grazing management planning and related issues should take into account the plant-animal interactions in the ecological system to help attain sustainable range management without ignoring other important environmental and social dimensions of the process (Fatur, 2009). An understanding of the components of the ecosystem including plants and animals and their dynamic interplay is key in coming out with strategies for managing natural rangelands. A complete investigation of plant/animal interaction during the various seasons of the year is therefore important for the proper setting of range management interventions. Also, an understanding of the feeding behaviour of animals will lead to the adaption of good management practices that could lead to maximum use of the existing ecosystem to increase animal production. The ability of grazing fields to meet the animals' pasture requirements will be of great benefit since most farmers do not practice feed supplementation.

The study was undertaken to:

1. Evaluate the effects of seasonality on species composition, biomass yield, physical properties and nutritive value of commonly grazed forages, crop residues, and water for the animals, in the given landscapes.
2. Determine the seasonal biomass production (DM) and the chemical composition of feeds and its digestibility in the given ecosystems and identify the commonly grazed forages and crop residues fed to rams in the study areas.

Materials and Methods

Study Area

The study was conducted in Nabdam, Bawku West, Kasena-Nankana Districts of the Upper East Region, and Kumbungu District of the Northern Region of Ghana. The study locations were grouped into Rain-fed and Irrigated landscapes Four landscapes (two rain-fed and two irrigated) with twelve ecosystems were selected. Each landscape was put into three (3) ecosystems (up-slope, mid-slope, and down-slope for the rainfed landscape and up-stream, mid-stream and down-stream for the irrigated landscape).

Selection of Grazing Sites, Biomass Yield Estimation and Chemical Analysis of Forage

The vegetative assessments were carried out according to Akapali (2018). Twelve (12) grazing sites were purposively selected in the four landscapes based on interaction with farmers and by direct observation. The biomass sampling area was selected within the main grazing zone of the pasture. A two-step sampling approach was used in the selection of sampling points within the grazing lands. The first step was to select five different plots of 50 x 50 m from each grazing land. The second step involved a random selection of sixteen (16) representative vegetation spots (0.25 x 0.25 m) in each 50 x 50 m plot. The biomass within the 0.25 m² frame was clipped to a stubble height of about 5 cm. The fresh weight of the harvested samples was recorded using a manual kitchen scale (Constant-14192, China). The samples were then air-dried for the dry weight to be measured and used for the determination of the dry matter (DM) yield. The dry weight together with the fresh weight was used to compute the biomass yield.

Percentage biomass yield (DM) = **(***Dry Biomass Weight/*

Wet biomass weight) x 100

The sampled forages, after drying were milled into 1 mm particle size. This was used for the determination of NDF, ADF, crude protein and ash. NDF and ADF were determined limited of residual ash through sodium sulfite and alpha amylase using the procedure of Van Soest et al. (1991) and this was done using Ankom^{200} fibre analyser (Method 5 for ADF and method 6 for NDF). Crude protein was determined using the Kjeldahl method of AOAC (2000).

Observation of Animal Behaviour During Grazing Faecal Sampling

The grazing behaviour of 36 Djallonké rams (Approx. I year old) was observed in the 12 ecosystems (3 rams per ecosystem). The rams were continuously observed for a day at 5 minutes interval for nine (9) hours without disturbance. Activities undertaken by the ram were recorded and categorized into five main groups as follows; feeding, walking, watering, resting and social interaction. Feeding (included grazing, chewing bite and browsing), walking (moving without feeding), watering (drinking of water), resting (ruminating, lying or standing without

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feeding or interacting) and social interaction (physical contact with other animals) (Akapali, 2018).
A tropicalized small ruminant faecal collection bag was fitted on the Djallonké rams in each ecosystem for 24 hours over a five-day period. Prior to actual faecal sampling, the animals were allowed 7 days adjustment to the faecal collection bags. The sampled faecal matter was bulked and sub-sampled for determination of faecal nitrogen following the procedure of AOAC (2000).

Live Weight Estimation of Djallonké Sheep

The initial live weight of the 36 rams was taken and recorded and subsequently recorded fortnightly for eight weeks in the dry and wet seasons of each landscape. The initial live weight of each ram was subtracted from the final weight to get the live weight gain. This was then divided by the duration of the study (60 days) to get the average daily live weight gain.

Statistical Analysis

The data on grazing behaviour were analyzed using the Kruskal–Wallis H test. Pairwise comparison was done by pairing two of the treatments at a time using the Mann–Whitney *U* test. Data on biomass yield, chemical composition were analysed as factorial design in ANOVA. In each landscape, season and ecosystem represented the two factors. In all cases, significant difference was declared at $p<0.05$.

Results and Discussions

There was a significant effect of ecosystem and season on plant height within the irrigated landscape (Table 1). Generally, the grazing lands were dominated with plants above 5 cm with the Up-stream ecosystems hosting most of these tall plants. The wet season had taller plants (79.2%) than the dry season within the irrigated landscape. There was a similar trend in the rain fed landscape with the mid-slope ecosystem having more plants that were above 5 cm in height (Table 2). Irrigation is a key input to agricultural growth. It plays a pivotal role in increasing crop productivity especially in the dry season for livestock and human benefit. The irrigated landscape recorded dominance at all the different plant heights (<1 cm, 5 cm and 5 cm and above) that were studied and this puts more emphasis on the importance of an irrigational facility to crops and livestock production. The dependence on rain-fed agriculture, particularly in northern Ghana, means that even though the production of the major staple food crops might be adequate in most years, seasonal food insecurity is widespread (www.awm-solutions.iwmi.org). The relatively lower heights (<1 cm) of forages observed in the rain-fed landscapes, especially in the dry season is an indication of high grazing pressure on the already heavily grazed pastures (Table 3). The importance of irrigated landscape has been felt and reported in the areas of food and nutrition security (crop and livestock), employment and poverty alleviation (Dittoh *et al,* 2013; Namara *et al,* 2011; Hussain and Biltonen 2001). The potential impacts of climate change on

Table 1. Plant Height in Different Seasons in the Ecosystems in the Irrigated Landscapes

Ecosystem	<1 cm	1-5 cm	>5 cm	X^2	Asymp. sig
Up-stream	5.2 (10)	31.2 (60)	63.5 (122)	32.798	0.000
Mid-stream	26.3 (42)	19.4 (31)	54.4 (87)		
Up-stream	5.2 (10)	31.2 (60)	63.5 (122)	45.909	0.000
Down-stream	32.1 (61)	20.5 (39)	47.4 (90)		
Mid-stream	26.3 (42)	19.4 (31)	54.4 (87)	7.794	0.050
Down-stream	32.1 (61)	20.5 (39)	47.4 (90)		
Season					
Wet	1.6 (4)	19.2 (49)	79.2 (202)	140.939	0.000
Dry	36.6 (105)	28.2 (81)	33.8 (97)		

** x^2- Pearson Chi-Square, Asymp. Sig-P-value, figures in parenthesis represent counts /frequencies. For each parameter, frequencies are compared among the ecosystems in the row.*

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Table 2. Plant Height in Different Seasons and Ecosystems in the Rain Fed Landscapes

Ecosystem	<1cm	1-5cm	> 5cm	X^2	Asymp. sig
Mid-slope	14.9 (31)	16.3 (34)	68.8 (143)	4.738	0.094
Up-slope	15.2 (34)	24.6 (55)	60.3 (135)		
Down-slope	33.9 (65)	13.5 (26)	52.6 (101)	22.661	<0.001
Up-slope	15.2 (34)	24.6 (26)	60.3 (135)		
Down-slope	33.9 (65)	13.5 (26)	52.6 (101)	19.729	<0.001
Mid-slope	14.9 (31)	16.3 (34)	68.8 (143)		
Season					
Wet	0.3 (1)	26.0 (75)	73.6 (212)	139.157	<0.001
Dry	38.4 (129)	11.9 (40)	49.7 (167)		

** x^2- Pearson Chi-Square, Asymp.Sig-P-value, figures in parenthesis represent counts /frequencies . For each parameter, frequencies are compared among the ecosystems in the row.*

rain-fed farming strategies versus irrigated systems are incomprehensible (FAO 2007). Another reason for the increase in plant height in the wet season might be the fact that the animals do not even get the chance to feed on the fields. Farmers that tend to practice mixed-farming tethered their livestock near their homes or a fixed spot in the grazing fields during the cropping season which is mostly the wet season to prevent crop damage.

Table 3. Mean Biomass Yield (DM kg/ha) in the Irrigated

Landscape	Ecosystem	Season	Biomass yield (DM kg/ha)
Irrigated	**Up-stream**	**Dry**	839.00
		Wet	3126.00
	Mid-stream	**Dry**	1089.00
		Wet	3461.00
	Down-stream	**Dry**	296.00
		Wet	3651.00
SED			*395.00*
P. value (Seasons)			*<0.01*
P. value (Ecosystem)			*0.467*
P. value (Season * Ecosystem)			*0.145*

SED: Standard error of difference, DM-Dry Matter. For each parameter, frequencies are compared among the ecosystems in each coloumn.

The lowest height observed in the dry season was expected since almost all grasses dry out in this season and the quality of available herbage is so low that, unless the animals have access to supplementary feeds, they lose weight. Additionally, a greater portion of these grazing lands, if not all, even end up being burnt during the dry season and this supports research by Maitima *et al., (*2009). Akapali *et al.,* (2018) reported that burning occurs mostly for two main reasons; firstly, by Fulani herders with the hope of stimulating plant re-growth for animals to have fresh forage to feed on. Secondly, by children, and occasionally, adults for hunting purposes. This also is in line with the assertion made by Nsiah-Gyabaah (1996).

The two-way effect of ecosystem by season interaction did not significantly affect biomass yield in the irrigated landscapes. However, there was a significant effect of season on biomass with the highest ($P<0.05$) obtained in the wet season of the irrigated landscape. These results conform to the findings in Sudan by Fatur (2009), where the peak wet season yielded higher amounts of biomass than the dry season.

The effect of ecosystem by season interaction on the biomass yield in the rain fed landscape was significant (Table 4). The wet season biomass was consistently higher than the dry season in all the ecosystems with the highest yield (6329 kg DM/ha) recorded in the wet sea-

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Table 4. Mean Biomass Yield (DM kg/ha) in the Rain Fed Landscape as Affected by Ecosystem and Season

Landscape	Ecosystem	Season	Biomass yield (DM kg/ha)
Rain fed	**Up-slope**	**Dry**	2083.00
		Wet	4153.00
	Mid-slope	**Dry**	1956.00
		Wet	6329.00
	Down-slope	**Dry**	1811.00
		Wet	3759.00
SED			*568.70*
P. value (Season)			*<0.001*
P. value (Ecosystem)			*0.003*
P. value (Season * Ecosystem)			*0.002*

SED: Standard error of difference, DM-Dry Matter. For each parameter, frequencies are compared among the ecosystems in each column.

son of the Mid-slope. This result contradicts that reported by Akapali *et al.,* (2018) who recorded low levels of biomass in the early rainy season. They attributed their result to residual effects of the previous dry season, bush burning and to some extent heavy grazing. They also suggested that higher dry season yields does not translate into good feed for animals since these plants are all mature with inadequate reserved energy, considering the fact that the carbohydrate in them would have been used up for flower, fruit and seed production, leaving highly lignified straw. The biomass yield recorded in the wet seasons of both rain fed and irrigated ecosystems were higher than the average biomass yield of 2170 kg DM/ha reported by Oppong-Anane (2006). This suggests that most of the biomass from natural pastures available for grazing livestock can be obtained in the wet season rather than in the dry season.

Figure 1 shows the mean effect of season on the grazing behaviour of Djallonké sheep within the rain-fed landscapes. There was a significant effect of season on feeding, watering and walking in the rain-fed landscape. The abundance of fodder on natural pasture during the wet season could account for the high percentage of time spent (45% wet season vs. 31% dry season) on feeding during the wet season in the rain fed landscape. The animals were found to have spent less time for watering (11% dry season vs, 8 % wet season) and walking (40% dry season vs. 30% wet season) in the rain-fed landscape during the wet season. This could be due to the availability of water and fodder so animals do not need to travel long distances to search for feed and water. These findings oppose the results of Akapali *et al.* (2018) who reported that cattle in the study area spent on average 66% of the grazing time on feeding, followed by walking (24%), resting (7%), social interaction (2%) and watering (1%). The longer proportion of time spent walking in the dry season can be due to the long distance often covered by

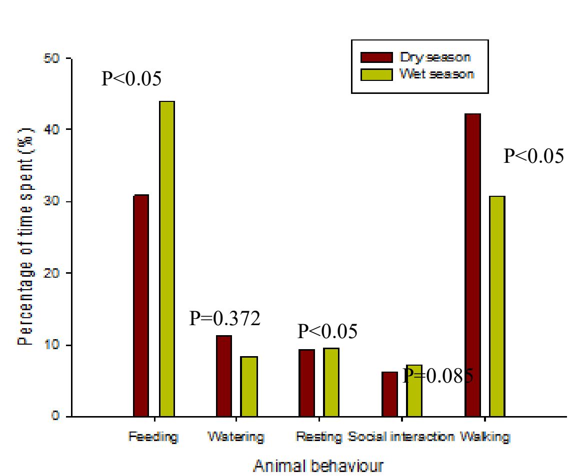

Fig 1. Seasonal Average Daily Percentage Time Spent on Grazing Behavior in the Rain-fed Landscape

animals to drinking water sources, which often becomes scarce in the dry season (Little and McPeak, 2014). This is an indication that, if watering points are provided in the dry season, the walking distance could be reduced and energy conserved for production.

In the wet season however, over 40% of the time was spent feeding and less than 40% pasture time on watering, resting and walking. The average proportion of time spent feeding and walking in the present study was similar to those reported by Feldt and Schlecht (2016) in a Madagascan study and Selemani *et al.,* (2013) in Tanzania. The fact that feeding took a greater proportion of the time spent by the animals grazing during the wet season is not surprising. According to Smith, (1988) animals are more likely to concentrate on meeting their energy requirements for maintenance first before engaging in any other activity. The rams spending more of their grazing time on feeding during the wet season than the dry season is expected, as fresh plants were just beginning to emerge, and longer time may be required for feeding to enable the animal to meet its energy requirement, and also, smaller but more bites are made when pasture is short and scattered (Gibb and Orr, 1997).

The effects of ecosystem on the behaviour of Djallonké sheep in the rain-fed landscape is shown on Figures 2a, 2b and 2c. With the exception of resting which was significantly higher in the up-slope ecosystem, the others were all not different. Animals in the upslope ecosystem

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of the rain-fed landscape spent more time (11% up slope vs. 9% mid slope) resting than those in the mid slope ecosystem. This result agrees with that of Akapali (2018)

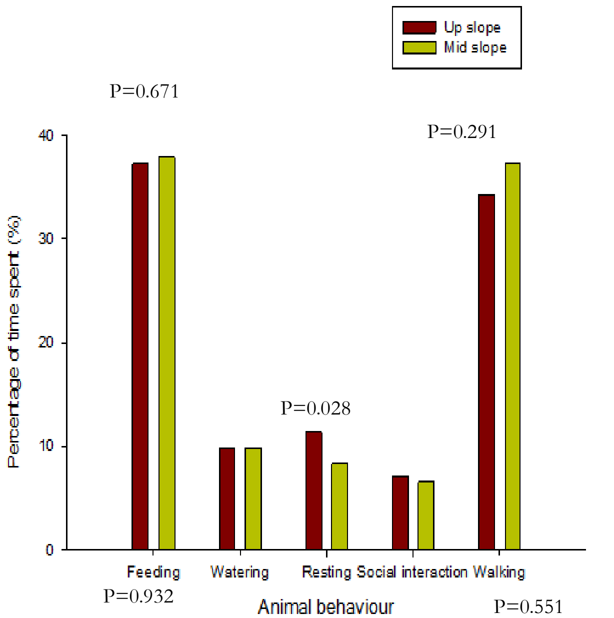

Fig 2a. Average Daily Percentage Time Spent on Grazing Behaviour in the Up-slope and Mid-slope Ecosystems of the Rain-fed Landscape

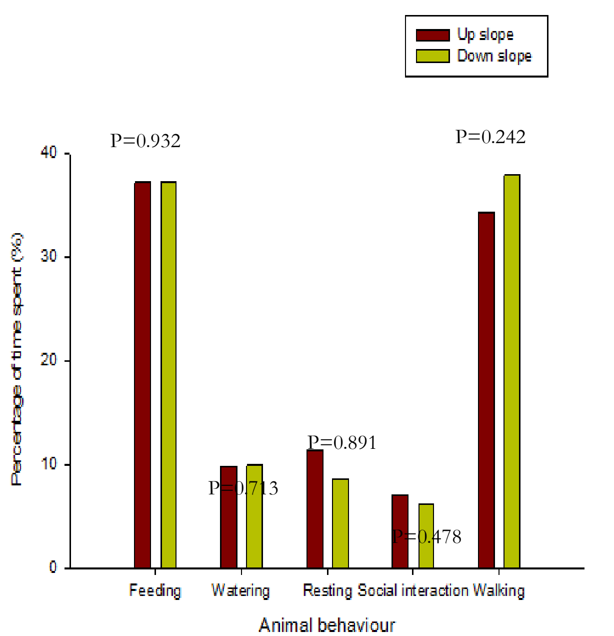

Fig 2b. Average Daily Percentage Time Spent on Grazing Behaviour in the Up-slope and Down-slope Ecosystems of the Rain-fed Landscape

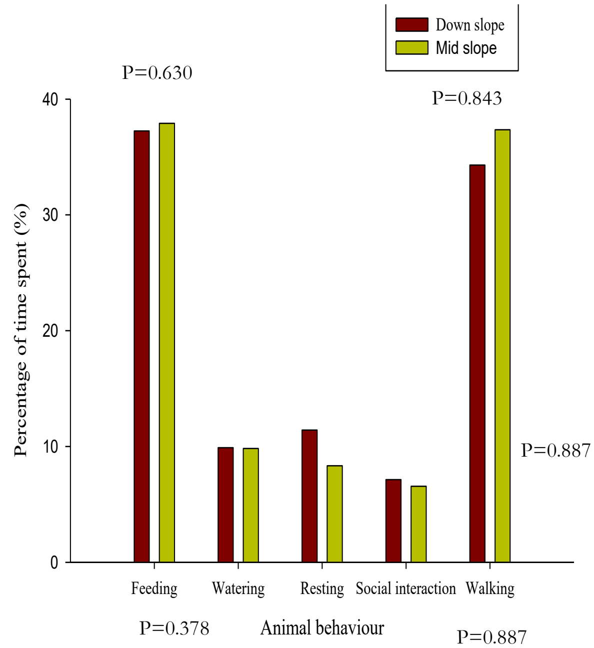

Fig 2c. Average Daily Percentage Time Spent on Grazing Behaviour in the Mid-slope and Down-slope Ecosystems of the Rain-fed Landscape

who reported a higher resting proportion in the peak rainy season (13%) than the intermediate (6%) and the dry season (2%). He attributed his results to the fact that during the peak rainy season, animals have abundant feed and water available and could, therefore, afford to spend more time resting as against the other parts of the season especially the dry season where animals had to continuously move about in search of feed and water. Grazing behaviour among other factors is determined by pasture quality/ availability and level of supplementation (SDSU, 2007), this might explain why less time was spent on grazing activities by rams in the rain-fed land-scapes. Considering that there was no difference in the feeding time between the two ecosystems, animals in the upslope ecosystem may convert the energy saved during resting for growth and production purposes. Generally, the study revealed that the choice of land for grazing, vegetation cover and biomass yield capacity varied from season to season. This has implications for the planning and choosing of appropriate feeding systems in order to enhance the productivity of ruminant livestock in the studied agroecosystems. The daily pasturing time on all the activities (feeding, watering, social interaction and walking) that was undertaken by the rams on the grazing fields during the study were not significantly affected

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(P>0.05) by the types of ecosystems in the Rain-fed landscape. fig 2c..

Within the irrigated landscape, season significantly affected the parentage time allocation to feeding, walking and watering (Figure 3). The ecosystem effects on the behavior in the irrigated landscape is presented in figures 4a, 4b and 4c. There was no significant effect of ecosystem on all the behavioural parameters estimated in the irrigated landscape. The Djallonké sheep studied spent more time feeding and less time walking in the wet season than in the dry season of the irrigated landscape. This could have a positive influence on the growth of the animals since energy gained from less walking could be used for growth purposes. Generally, the time allocation for various grazing activities within the ecosystems of the irrigated landscape were similar suggesting that ecosystem services from small ruminant production in the irrigated landscapes are not different.

Table 5 showed that the chemical composition of the mixture of fodder harvested from natural pasture and crop residues within the rain-fed landscape were not significantly affected by the two-way ecosystem and season interaction except the dry matter (DM). The main effect of season however, was significant with the wet season recording higher CP than the dry season.

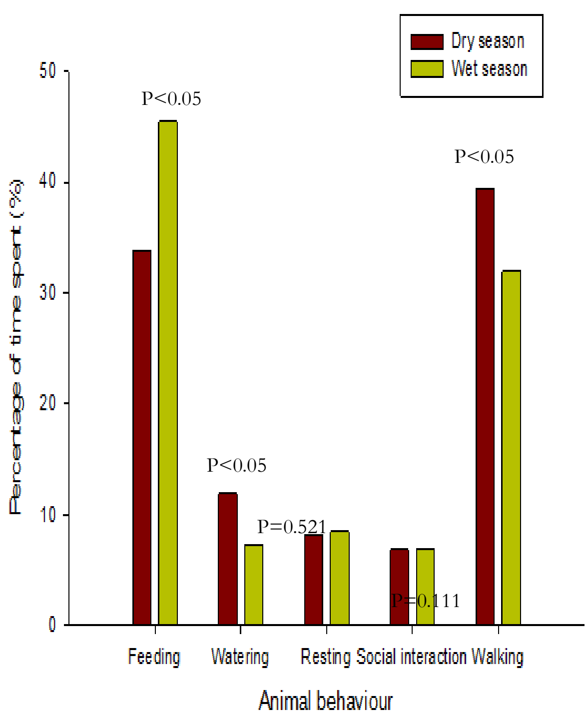

Fig 3. Seasonal Average Daily Percentage Time Spent on Grazing Behaviour in the Irrigated Landscape

The two-way interaction effect of ecosystem and season was not significant for any of the nutritional parameters in the Irrigated landscapes. However, with the exception of dry matter (DM) which recorded higher values in the dry season, the main effect of season was significant with the wet season recording higher neutral detergent fiber (NDF), acid detergent fiber (ADF) and crude protein (CP) than the dry season.

Lignin was not quantified in this study. However it could be a contributor to differences in the nutritive values. Plants with relatively longer days to maturity often accumulate more stem mass than leaves. Stems of most forages have higher concentration of non-photosynthetic tissues with higher lignin concentration (Wilson and Kennedy, 1996). Since season (early, mid or late) has an influence in the quantity of lignin (fiber) in a forage, it may have accounted for the differences that were recorded especially for DM. Again, grazing behaviour among other factors is determined by pasture quality/ availability and level of supplementation (SDSU, 2007). Sheep (rams) being selective feeders will select preferred plant species (Thorne *et al.,* 2007) and hence could have also attributed to higher DM recorded in the dry season. Although CP values in the wet season were higher than the dry season as shown in table 6, the concentrations were below the minimum range of CP (11.1% to 13.0%) required for the maintenance and growth of small ruminants (Van Soest, 1982; NRC, 2007) except the CP concentrations recorded in the Up-stream ecosystem. which suggests that animals in this landscape would need to be supplemented to promote growth of small ruminants.

The ecosystem by season interaction effect on final weight, final weight gain and average daily weight gain in the irrigated landscape was not significant (Table 7). Season on the other hand had a significant effect on all the growth parameters. The animals had higher final weight (16.56 vs 15.08 kg), final weight gain (3.27 vs 2.28 kg) and average daily weight gain (54.5 vs 38.1 g) in the wet season than in the dry season in the irrigated landscape. This result corresponds to that of Annor *et al.,* (2007) who indicated that, in the savanna zone of Ghana, bush fires and decline in nutritive value of fodder resulting from senescence makes it difficult for livestock to meet their nutritional requirement in the dry season under the existing extensive and free-range management systems practiced by most smallholder farmers, especially when many of the animals reared in northern Ghana survive mainly on left over straw during the dry season. Situations like these have made feed for livestock to be the main constraint to improved productivity in the smallholder systems. There is therefore, the need for feed

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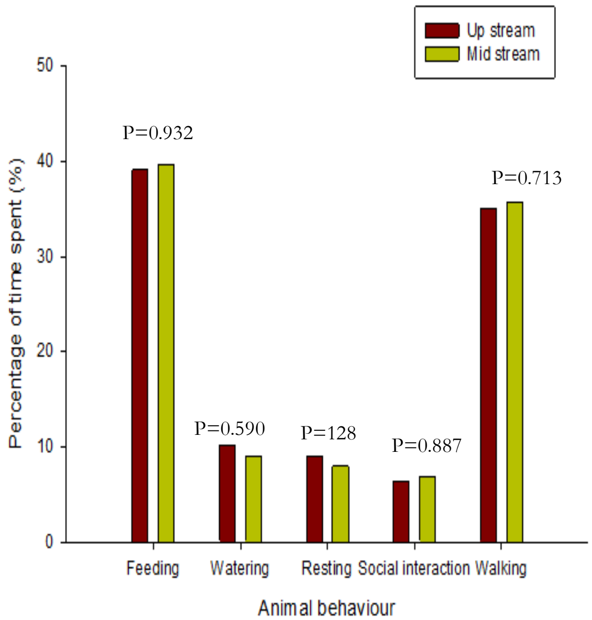

Fig 4a. Average Daily Percentage Time Spent on Grazing Behaviour in the Up-stream and Mid-stream Ecosystems

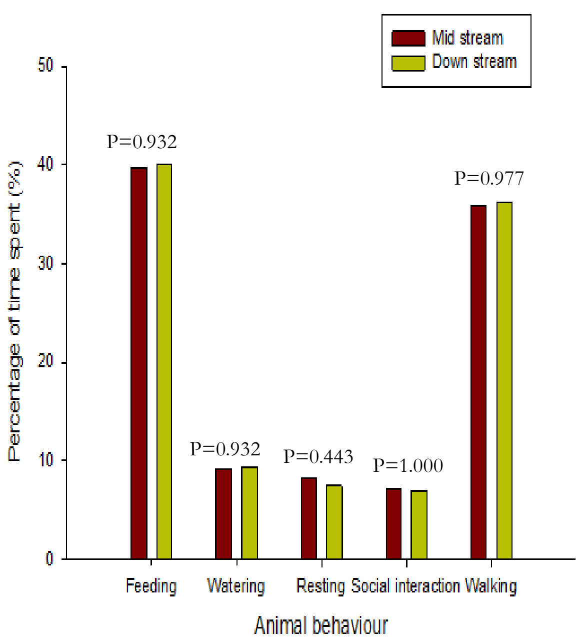

Fig 4b. Average Daily Percentage Time Spent on Grazing Behaviour in the Down -stream and Mid-stream Ecosys-

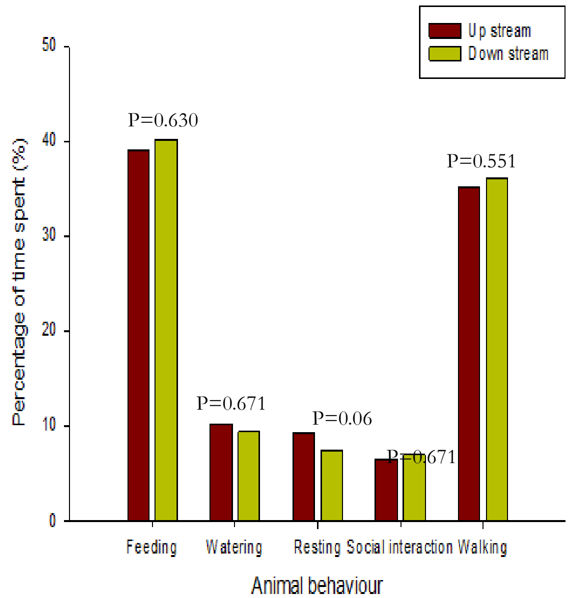

Fig 4c. Average Daily Percentage Time Spent on Grazing Behaviour in the Up-stream and Down-stream Ecosystems of the Irrigated Landscape

supplementation of ruminant during the dry season to maintain or improve weight gain but then supplementation often relies on the energy-rich grains and these are often scarce, expensive and not economical to use (Karbo *et al.,* 2002). The way out will be to research agro-industrial by-products and/or crop residues that are not used by humans and non-ruminants and can be used for supplementing ruminants.

In the rain fed landscape, the effects of the ecosystem and season interaction was again not significant. There was however a significant effect of season on the growth parameters (Table 8). Djallonké sheep had higher final weight gain (2.8 vs 2.3 kg) and average daily weight gain (46.9 vs 39.4 g) in the wet season than in the dry season in the rain-fed landscape. This result is in conformity to Annor *et al.*'s (2007) observation that, ruminants gain weight in the rainy season because of the availability of abundant green natural pasture which is nutritionally rich and they lose weight in the dry season due to low-quality fodder which is compounded by its unavailability. Season in this context did not determine the quantity of feed especially natural forages that are made available to ruminants during the wet or cropping season when there are abundant

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Table 5. Ecosystem and Season Effect on Mean Chemical Composition of Small Ruminants Feed and Manure Crude Protein in the Rain-fed Ecosystems

	Parameters	DM (%)	NDF (%)	ADF (%)	CP (%)
Wet season	**Up-slope**	22.53	62.51	36.77	14.52
	Mid-slope	22.06	62.73	46.23	15.66
	Down-slope	22.33	53.58	41.00	9.54
Dry season	**Up-slope**	88.31	52.52	35.47	2.43
	Mid-slope	91.50	54.37	33.57	2.60
	Down-slope	92.33	55.30	41.03	2.71
SED		0.848	0.262		1.145
P-value	**Ecosystem**	<.001	0.642	0.466	0.022
	Season	<.001	0.868	0.191	<.001
	Ecosystem * Season	<.001	0.262	0.286	0.017

SED- Standard error of differences, CP- Crude Protein, NDF-Neutral Detergent Fiber and ADF-Acid Detergent Fiber. For each parameter, frequencies are compared among the ecosystems in each column.

Table 6. Ecosystem and Season Effect on Mean Chemical Composition of Small Ruminants Feed and Manure Crude Protein in the Irrigated Ecosystems

	Parameters	DM (%)	NDF (%)	ADF (%)	CP (%)
Wet season	**Up-stream**	22.42	75.0	47.1	12.64
	Mid-stream	22.54	58.8	58.8	10.59
	Down-stream	22.57	62.1	47.1	10.59
Dry season	**Up-stream**	73.90	46.1	39.1	3.25
	Mid-stream	73.70	48.8	48.8	3.50
	Down-stream	74.13	46.1	39.1	4.00
SED		1.218	9.29	7.67	0.718
P-value	**Ecosystem**	0.332	0.292	0.203	0.264
	Season	<.001	0.008	0.051	<.001
	Ecosystem * Season	0.220	0.839	0.971	0.069

SED- Standard error of differences, CP- Crude Protein, NDF-Neutral Detergent Fiber and ADF-Acid Detergent Fiber. For each parameter, frequencies are compared among the ecosystems in each column.

Table 7. Growth Performance of Djallonké Rams in Ecosystems Within Irrigated Landscapes

	Parameters	Initial weight (kg)	Final weight (kg)	Final weight gain (kg)	Average daily weight gain (g)
Ecosystem	**Down-stream**	12.9	15.6	2.6	44.4
	Mid-stream	12.9	15.9	2.6	50.1
	Up-stream	13.2	15.9	2.5	44.3
Season	**Dry**	12.8	15.0	2.2	38.1
	Wet	13.2	16.5	3.2	54.5
SED		0.478	0.375	0.389	6.49
P-value	**Ecosystem**	0.479	0.386	0.362	0.362
	Season	0.086	0.001	0.001	0.001
	Ecosystem Season	*0.332	0.416	0.428	0.428

SED- Standard error of differences, CP- Crude Protein, NDF-Neutral Detergent Fiber and ADF-Acid Detergent Fiber. For each parameter, frequencies are compared among the ecosystems in each column.

Table 8. Effect of Interaction Between Ecosystems on Growth Performance of Djallonké Rams in Rain-fed Landscapes

Parameters		Initial weight (kg)	Final weight (kg)	Final weight gain (kg)	Average daily weight gain (g)
Ecosystem	**Down-slope**	12.9	15.5	2.6	43.9
	Mid-slope	12.5	15.2	2.6	44.8
	Up-slope	12.9	15.3	2.4	40.8
Season	**Dry**	12.9	15.3	2.3	39.4
	Wet	12.6	15.4	2.8	46.9
SED		0.28	0.36	0.26	4.48
P value	**Ecosystem**	0.154	0.511	0.422	0.422
	Season	0.118	0.399	0.008	0.007
	Ecosystem * Season	0.143	0.442	0.102	0.102

SED- Standard error of differences, CP- Crude Protein, NDF-Neutral Detergent Fiber and ADF-Acid Detergent Fiber. For each parameter, frequencies are compared among the ecosystems in each column.

natural feed resources and the dry season when feed is scarce and unavailable because they get tethered and uncared for since the main activity of the smallholder farmer is growing of food crops, (Attoh-Kotoku, (2003).

Conclusion

This study has brought to the fore the relationship between season, irrigation, and ecosystems on forage characteristics and animal production. Generally, the grazing lands in the irrigated ecosystems dominated at all the different plant heights (<1cm, 5cm and 5cm and above) that were studied and this puts more emphasis on the importance of an irrigational facility to crops and livestock production. Feeding, watering and walking by the rams were affected by season in both landscapes. The animals were found to have spent less time for watering and walking in the rain-fed landscape during the wet season. This could have a positive influence on the growth of the animals since energy gained from less walking could be used for growth purposes. The time allocation for various grazing activities within the ecosystems of the irrigated landscape were similar suggesting that ecosystem services from small ruminant production in the irrigated landscapes are not different. Season affected the final weight gain and average daily weight gain in the wet season in both landscapes.

Competing interest

The authors declare no potential conflicts of interest with respect to the authorship and/or publication of this article.

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