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West Africa Dwarf sheep management systems and exposure to potential stressors in the savannah agroecological zone of Ghana

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ABSTRACT

This study was conducted in the savannah agroecological zone of Ghana to assess the different sheep management systems and identify potential stressors that compromise sheep productivity under these systems. A questionnaire and on-farm observations were used to obtain data from 176 farms on management system types, resources, husbandry practices and productivity. Four management systems were identified in the study area, namely extensive (41.5%), semi-intensive (38.1%), intensive (6.3%) and tethering (14.2%). Feeding systems used were free grazing/scavenging (24.43%), herded grazing (17.05%), zero-grazing/intensive feeding (6.25%), grazing plus supplementation (38.07%) and restricted grazing in the rainy season (14.2%). Most (87%) farmers under the extensive system did not house their sheep at all, but 88.1% of farmers using the semi-intensive system housed their sheep year round. Floor spacing per sheep was 1.06, 2.31, 2.17 and 1.47 sheep/m^2 for the intensive, semi-intensive, extensive, and tethering, respectively. Preweaning mortality was significantly higher (40%) than post-weaning to yearling (34.9%) and adult mortality rates (14.3%) (χ^2 = 292, P <0.001). The extensive system has the highest (32.8%) mortality rate and the intensive system the least (14.9%) (χ^2 = 151, P <0.001). Reproductive indices (lambing percentage, age at first lambing, lambing intervals, and abortion rates) were all significantly influenced by the management system, with sheep managed under the semi-intensive and intensive systems performing better than sheep managed under the extensive system and tethering. Extensive management and tethering of sheep may expose Djallonké sheep to disease stress, chronic undernutrition, heat stress and walking stress compared to sheep under more intensive systems.

***Key words**: Djallonke sheep, environmental stress, temperature humidity index (THI), reproductive performance*

INTRODUCTION

Small ruminants constitute an important component of animal agriculture in Ghana. Their contribution to total livestock output is estimated to be about 30% (Ghana Statistical Service, 2019). In northern Ghana, where they are widely reared, small ruminants are valued for their contribution to food security, income generation, their use as insurance against crop failure, and for socio-cultural and religious purposes. Although small ruminant rearing is usually associated with rural areas of Ghana (Avornyo et al., 2007), production in peri-urban and urban areas has increased steadily, with estimates putting urban household ownership of small ruminants between 13% and 25% of national output (Baah et al., 2012; Ghana Statistical Service, 2019). Small ruminants enjoy a steady market in northern Ghana, and hold significant promise as a species that could help alleviate poverty if productivity is improved (Adogla-Bessa et al., 2005; Adams et al., 2021).

Productivity of indigenous sheep in Northern Ghana is low under the prevailing low-input management systems and harsh environmental conditions (Osaer et al., 2000; Agyei, 2003; Konlan et al., 2017) due to the use of the extensive and free-range systems, with low investment in feed, healthcare and suitable housing. Sheep management systems are not homogenous, and the generally recognized ones are the extensive, semi-intensive and intensive systems (Adzitey, 2013; Adams and Ohene-Yankyera, 2015), based on the level of intensification (access to improved pasture, supplementary feeding, provision of veterinary health care) and degree of confinement of sheep (free-roaming, partial or total confinement) (Karbo and Agyare, 2002).

The farm environment and management expose farm animals to different levels and types of stressors, including biotic stressors (poor feed availability, exposure to predators or the existence of pathogens) or abiotic stressors such as extreme temperatures, reduced water availability and exposure to toxicants. Assessing the resource base and production practices of sheep farms could therefore provide some clues as to the kinds of stressors sheep are exposed to and their effects on the efficiency of production and welfare of the animal.

This survey is therefore an appraisal of the production system environment, resources and practices which will highlight the potential stressors sheep are exposed to under the prevailing management systems in 5 districts in the Northern Region of Ghana.

MATERIALS AND METHODS

Location of study

The study was conducted in 5 administrative districts in the Northern Region of Ghana, namely, Savelugu, Tolon, Kumbungu, Sagnarigu and Tamale Metropolis.

Agroclimatic conditions of the study area

The study area is a typical Guinea Savannah agroecology, with a unimodal rainfall pattern. The mean annual rainfall ranges from 1000 to 1100 mm. The rainy season occurs between April and October, starting with an initial irregular pattern and reaching a peak in August and September. The dry season lasts from late October to April and has a cold period lasting from November to February and a hot period from March to May. Mean recorded temperature, humidity and temperature-humidity index (THI) are shown in Table 1.

Table 1: Mean temperature, humidity and temperature humidity index (THI)

Parameter	Time of day			Season	
	8:00am	12:00pm	3:00pm	Wet	Dry
Ambient temperature (°C)	28.49 ± 0.29	32.56 ± 0.38	33.44 ± 0.38	29.77 ± 0.28	32.82 ± 0.34
Humidity (%)	62.10 ± 2.56	54.48 ± 2.39	51.94 ± 2.33	73.18 ± 0.88	43.23 ± 1.74
THI	26.77 ±0.244	29.83 ± 0.255	30.43 ± 0.24	28.40 ± 0.22	29.48 ± 0.25

Source: Field data

Sampling of study sites

The 5 administrative districts were selected based on their high small ruminant numbers (450,000) (Ghana Statistical Service, 2019) and potential for improving production to feed major market centers (DFID, 2014). The sampling frame comprised a list of small ruminant farmers in the study districts compiled by the Animal Production Departments of the administrative District Assemblies. A total of 176 farmers were randomly selected for interviews.

Classification of management systems

Management system classification was based on grazing management (free-roaming, or zero-grazing), provision of supplementary feed (provision of or absence of) and degree of confinement (ownership of sheep housing facility and whether sheep were housed overnight or not). Tethering was considered a standalone management system as it is practiced for 6 months within the year and could expose sheep to unique stressors. Sheep were considered to be under intensive management if they were housed overnight and throughout most of the day, stall-fed without any grazing (zero-grazing) (Economides, 1986; Adams, 2015). Sheep managed semi-intensively were housed overnight for most of the year and offered supplementary feed. The extensive system was characterized by farmers exercising minimal control over the movement of their sheep and not providing feed supplementation (Karthik et al., 2021). Flocks that were tethered in the rainy season on communal pasture or along road margins to graze throughout the daytime in the rainy season were classified under tethering.

Data collection

Questionnaire survey

A structured questionnaire was used to interview farmers to obtain information on flock sizes, production system environment and resources (feed resources and feeding strategies, housing, veterinary health care, daily mean temperature and humidity readings), husbandry practices, disease prevalence and treatment regimes, reproductive and breeding management.

On-farm observations and measurements

Follow up visits to farms were done to observe husbandry, feeding and animal health care practices and to take physical measurements of sheep housing units. The floor allowance for sheep pens was estimated by measuring the length and breadth of housing built in the rectangular style, and then computing the area as follows:

A = L x B, where A= area of rectangular pen (m^2), L = length of pen (m), B = breadth of pen (m). For sheep housing built in the round style, the inner diameter of the room was measured with a measuring tape and used to compute the area using the formular for computing the area of a circle:

A = πd, where A = area of the circle (m^2), π = 3.142 and d = diameter of the pen (m).

The number of sheep kept in the flock was then divided by the floor area to determine the number of sheep per square metre.

Communal grazing areas of sheep flocks were visited, and feed samples taken in the manner described by Konlan et al. (2018). Briefly, commonly grazed species in each community were harvested by observing the forage species consumed by sheep at pasture. Samples of the forages were harvested, bulked by community and sub-sampled for laboratory analysis. Fresh forages harvested for stall feeding and samples of supplementary feeds offered by farmers were catalogued and sampled for chemical analysis as well. Chemical analysis was conducted at the International Livestock Research Institute (ILRI) laboratory (Burkina Faso) using Near Infrared Spectroscopy (NIRS).

Flock productivity indices
Flock productivity indices such as lambing rate, mortality rate and abortion rate were calculated as follows:

$$\text{Mortality rate} = \frac{\text{Number dead}}{\text{Total flock}} \text{ x } 100$$

$$\text{Lambing rate} = \frac{\text{Number of lambs born}}{\text{Number of breeding ewes}} \times 100$$

$$\text{Abortion rate} = \frac{\text{Number of abortions}}{\text{Number of pregnancies}} \times 100$$

Statistical analysis.
The data obtained from the survey were analyzed as frequencies and presented using tables and figures. Where farmers were asked to rank several options, such data were analyzed using Kendall's W test for non-parametric tests. Normally distributed data such as age at first lambing and lambing intervals were analyzed using ANOVA, with the production system as the factor. Means found to be statistically significant at a 5% level of significance were separated using the Student-Neuman-Keul's Test. The strength of association between variables with logical relationships was tested using the Chi-squared test of the association at a 5% level of significance.

RESULTS AND DISCUSSION

Sheep management systems
Table 2 shows the proportion of respondents practicing the different management systems identified in this study. The extensive system was the most popular system (41.5%) while the intensive system was the least used by farmers (6.3%). Rainy season tethering was practiced by 14.2% of farmers.

Table 2: Proportion of farmers using the different management systems

Management system	Number of farmers	Percentage of farmers (%)
Extensive	73	41.5
Semi-intensive	67	38.1
Intensive	11	6.3
Tethering*	25	14.2
Total	176	100

**Practiced in the rainy season only*

The classification of management systems closely resembles the criteria used by Economides (1986) and Karthik et al. (2021). The extensive system has been considered as the traditional system for decades (Dettmers, 1983; Devendra, 1986; Ajala et al., 2008), and was found to be the most popular system in this study. The persistence of the extensive system over the years may be attributed to the relatively little investment required under this system and the availability of natural rangelands for grazing. Sheep farmers who cannot spare the household labour to herd sheep, resort to tethering their sheep in the rainy season while farmers who have the labour prefer to have their sheep herded to communal pastures for grazing. The practice of tethering sheep was only done in the rainy season. Few farmers practiced the intensive system probably because of the cost involved in purchasing feeds and medication (Ajala et al., 2008).

Husbandry practices

Feed resources and feeding

The main systems for feeding sheep were characterized as shown in Table 3. Sheep managed under the extensive system either roamed freely (58.9%) or were herded by boys to communal pastures to graze (41.1%) during the rainy season. Under the semi-intensive system, sheep were given some supplementary feed in addition to the grazing of natural pasture. Tethering sheep at pasture during the daytime in the rainy season was practiced by 14.2% of farmers. Sheep that were managed intensively were fed harvested fresh grass species, legumes, or tree fodder (Table 5). In the dry season, crop residue was fed to intensively and semi-intensively managed sheep.

Table 3: Characterization of feeding practices under the different management systems

Feeding mode	Management system			
	Extensive (n=73)	Intensive (n=11)	Semi-intensive (n=67)	Tethering (n=25)
Free grazing/scavenging	58.9	0	0	0
Herding for grazing	41.1	0	0	0
Grazing + supplementation	0	0	100	0
Stall feeding/zero-grazing	0	100	0	0
Restricted grazing	0	0	0	100

There was a strong association between management systems and the use of special/separate feeding practices (Table 4). Farmers under the intensive system were more likely to practice separate feeding of lambs, lactating, and pregnant animals (χ^2 = 46.7, 71.07 and 18.31, respectively (Table 4) compared to other management systems. Twenty-seven (27%) of farmers using the intensive system offered mineral lick, but only few farmers under the semi-intensive system offered salt lick to their sheep (3%) (χ^2 = 45.78, P = 0.000).

Figure 1 shows the significant change in the quality of natural pasture in terms of crude protein content and digestibility (P<0.01) from the rainy season to the dry season. Crude protein content of pasture declined from 13% to 5% in the dry season while in vitro organic matter digestibility (IVOMD) declined from 56% in the rainy season to 34% in the dry season.

Table 4: Association between management systems and special feeding practices

Special feeding practices	Management system				χ^2	P value
	Intensive	Semi-intensive	Extensive	Tethering		
Separate feeding of lambs	72.7	26.9	0.0	0.0	46.74	<0.000
Separate feeding of lactating ewes	100.0	26.9	0.0	0.0	71.07	<0.000
Separate feeding of pregnant ewes	27.3	10.4	0.0	0.0	18.31	<0.000
Provision of mineral lick	27.3	3.0	0.0	0.0	45.78	<0.000

Table 5: Types and categories of feeds and forages fed to sheep

Class of feeds	Species/types	Local/common names
Natural pasture composition (heterogenous pasture)	*Andropogon gayanus*	Thatch grass
	Pennisetum pedicellatum	Nigeria grass (Chima)
	Rottboelia cochinchinensis	Itch grass
	Tephrosia purpurea	Tephrosia
	Digitaria ciliaris	
	Amaranthus spinosus	Spiny amaranth
	Sida acuta	Broom weed
Harvested grasses and legumes	*Andropogon gayanus*	Thatch grass
	Pennisetum pedicellatum	Nigeria Grass
	Rottboelia cochinchinensis	Itch grass
	Stripped Maize leaves	Maize
	Tephrosia purpurea	Tephrosia
Tree fodder	*Glyricidia sepium*	Glyricidia
	Ficus gnarpharlocarpa	Ficus
	Mangifera indica	Mango

	Securinega setigera	Common bushweed (Susugra)
Crop residue	Groundnut haulm Pigeon pea waste Cowpea pods	
Agro-industrial by products	Rice bran Corn chaff Corn mill waste	
Other	Kitchen waste	

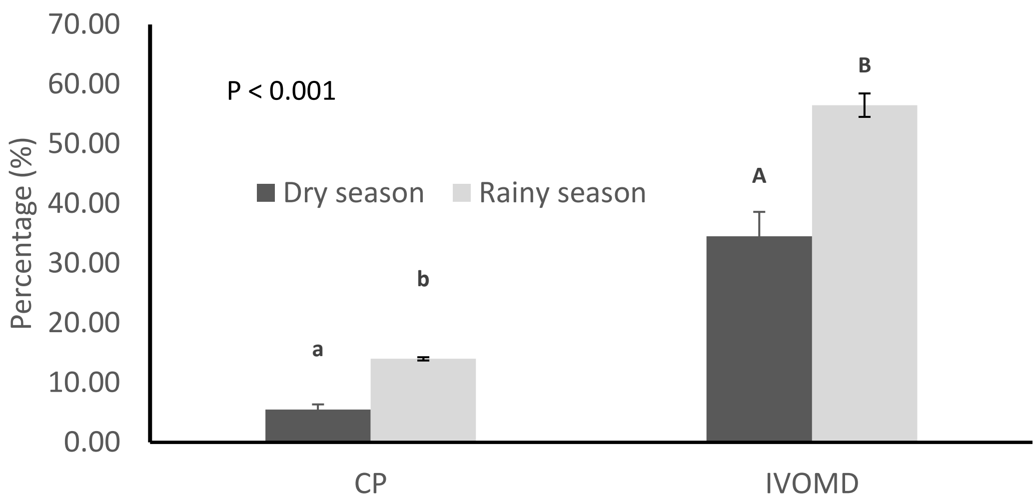

Figure 1: Crude protein (CP) and *in vitro* organic matter digestibility (IVOMD) of natural pasture across two seasons (Error bars = standard errors).

The feeding systems used by farmers were largely dependent on the management system farmers practiced. This has been reported in several studies (Devi et al., 2020; Karthik et al., 2021). Sheep in northern Ghana mostly rely on natural pasture to meet their nutrient requirements under the extensive or traditional management system (Konlan et al., 2017). Under the extensive system, sheep flocks roam free for the most part, especially in the dry season months, but during the rainy season, when movement of small ruminants has to be restricted to prevent crop destruction in some areas, sheep are either herded to communal rangelands to graze or tethered (Amankwah et al., 2012).

Sheep would normally spend much of the daytime grazing to meet their nutrient requirements (Gebremariam and Belay, 2016), but as communal grazing areas have reduced in size due to increasing pressure on land for alternative uses, the semi-intensive system has emerged, as farmers have adopted intensification practices such as feed supplementation with crop residue and agro-industrial by products to augment natural pasture which is inadequate to support productive performance (Baah et al., 2012; Adams, 2015). The farmers who offered supplementary feed did so based on the availability and affordability of feed and not necessarily on the needs of the animal.

During focus group discussions in this study, an often-cited reason farmers gave for providing supplementary feed was to prevent their sheep from roaming far from the homestead in search of feed and thereby going missing or stolen. The amount of feed offered was however *ad hoc* and token.

In the urban areas of Kumasi, Baah et al. (2012) found that 45% of farmers practiced hand feeding and cut-and-carry (intensive system), compared to only 11% of farmers in this study. The small number of farmers practicing intensive feeding may be due to the labour and cost intensive nature of carting feed to the home and the cost of feed. Tethered sheep depended only on natural pasture within the limits of their tethering rope.

The natural vegetation grazed by sheep in the study sites was of a heterogenous composition (mixture of grasses, legumes and forbs) whose botanical composition match those previously identified by Ziblim et al. (2015) and Konlan et al. (2018). The changing quality of feed from the rainy to the dry season has been previously reported by Konlan et al. (2018), who showed that available biomass and nutritional value of natural vegetation declines from the rainy to the dry season due to the changing rainfall pattern. In the tropics, natural vegetation is considered poor in quality as it often matures and senesces before it is used by livestock (Phillips, 2016). As plants mature there is an associated increase in indigestible components such as lignin and a reduction in soluble sugars and nitrogen (Minson, 1990). Konlan et al. (2018), again reported a significant decline in crude protein by up to 4 times from the rainy season to the dry season, while digestibility declined by 35%. For sheep managed under the extensive system therefore, sole dependence on natural pasture, especially during the dry season may expose sheep to nutrition stress leading to weight loss and reduced reproductive performance. Amankwah et al (2012), previously reported the practice of tethering sheep in the rainy season to prevent crop destruction. Tethering is a response to labour shortage in farm households since most farmers would prefer to have their animals herded to pastures to graze rather than tether them. Although the practice is more common in goats than sheep, (Ogede et al., 2000), shortage in household labour results in the tethering of sheep. This practice limits the availability and choice of forage, ironically during the period when natural pasture is most abundant. In this study, more abortions and lamb deaths were reported among sheep that were tethered in the rainy season, which may be an indication of nutritional stress. There is a paucity of data on the effect of tethering on the nutritional status and productivity of sheep, despite the prevalence of the practice in managing small ruminants and the perception among farmers that the practice is deleterious to sheep performance.

Table 6 shows the sources, frequency of watering and distances sheep trekked to find water and feed. The main source of water for sheep under the Extensive system was from dams/dugouts (65.75% of respondents) while under the Semi-intensive and Intensive systems, most farmers (72.73% and 70.15%, respectively) said they used pipe-borne water. Most farmers practicing the Extensive system (76.23%), Semi-intensive system (59.7%) and Tethering (56%) watered their animals whenever they returned to the homestead from grazing but farmers using the Intensive system offered water *ad lib* while some provided it twice per day (9.09%) or thrice (27.27%). All farmers (100%) indicated water shortage as a major constraint during the dry season months.

Table 6: Water source and frequency of watering

Variable	Extensive	Intensive	Semi-Intensive	Tethering
Source of water				
Pipe borne	4.92	72.73	70.15	12.70
Well	9.59	0	2.98	0.00
Dam/dug out	82.75	9.09	23.88	80.00
Borehole	2.74	18.18	2.99	7.30
Frequency of watering				
Always available	2.74	63.64	8.96	0
Once per day	10.5	0	10.45	44.00
Twice per day	5.48	9.09	13.43	0
Three times per day	5.05	27.27	7.46	0
When sheep return from grazing	76.23	0	59.70	56.00
Distance to water source				
0 (Home)	24.25	100	58.97	100
1-2km	57.85	-	33.07	-
2-5km	11.6	-	6.96	-
>5km	6.3	-	-	-

The source of water was management system related; whereas most farmers under the intensive and semi-intensive systems used pipe-borne water, those under the extensive system and tethering relied on dams and dugouts for water. Sheep under the extensive and semi-intensive management systems roamed quite far from home and could be observed drinking water from open sewage and drain ways, possibly exposing them to chemical toxicants in these sources. The farmers interviewed alluded to chemical poisoning of their sheep through ingestion of sewage water containing cosmetics washed out into drains. According to Amankwah et al. (2012) small ruminant farmers provided water at home as a strategy to monitor their animals and to ensure that they detect any missing animals. In most human habitations, water shortage is common even for human consumption, especially in the dry season months, and it is not surprising that most farmers reported that providing water for sheep was a constraint.

Housing of sheep

All flocks being managed under the intensive systems were provided with housing throughout the year compared to 88% of farmers using the semi-intensive system (Table 7). Most (87%) farmers practicing the extensive system did not house their sheep, regardless of the season. However, about 13% of farmers using the extensive system provided simple housing for their animals for the rainy season period only.

Table 7: Percentage of farms housing animals across management systems

Housing	Extensive (n*=73)	Semi-Intensive (n=67)	Intensive (n=11)	Tethering (n=25)
Year-round housing (%)	0	88.1	100	0
Seasonal (wet season only) (%)	13	11.9	0	80
No housing (%)	87	0	0	20

*n – number of farms

Most farmers used locally available materials such as mud and thatch to construct the walls and floors of their pens and corrugated metal sheets for roofing. Most (84.8%) of the floors of sheep housing were bare earth. The floor allowance per animal was 1.06, 2.31, 2.17 and 1.47 sheep/m^2 for the intensive, semi-intensive, extensive, and tethering, respectively. About half of the farmers (55%) who owned pens provided bedding material; 78% of them used rice husk, 15% used rice straw and 7.4% used wood shavings as bedding material. More than half of the farmers who owned pens (58.62%) cleaned them weekly; 21% cleaned once every month, and 15% cleaned sheep pens every day. About 5% of farmers had no definite interval for cleaning pens and only did so when they felt the need.

Providing adequate comfort for sheep is considered key to good welfare and productivity in sheep. However, literature on housing requirements for sheep in Sub-Saharan Africa is rare, perhaps due to the general culture of not housing ruminants under the mostly extensive system of management (Adams, 2015). Adequate floor space, suitable flooring and bedding material and proper ventilation are important in livestock housing design. The floor allowance for sheep in this study fell short of the recommended floor spacing of 1m^2/animal reported by Karthik et al (2021). The only ventilation was provided by a low doorway and narrow slits/holes cut into the mud/brick housing, which may be inadequate for natural ventilation to be effective in removing noxious gases such as CO_2 and NH_3 which are produced through respiration and urine accumulation (Koluman and Daskiran 2011). Sheep sleeping on bare earth in the pens may facilitate worm egg build up in the pens as reported by Squire et al. (2019), who identified the use of bare earth flooring as a significant risk factor for the prevalence of helminth infections among sheep flocks in the coastal Savannah of Ghana.

Health management

All the farmers interviewed had experienced disease within their flocks in the preceding 12 months. Diarrhoea was ranked as the most important disease condition encountered by farmers, regardless of the system of management (Table 8). Pneumonia/respiratory conditions were ranked as the second-highest disease condition farmers experienced under the intensive and semi-intensive systems, while foot rot was considered the second most common condition experienced by farmers practicing the extensive system and tethering.

Table 8: Disease conditions frequently encountered by farmers by management system

Disease/condition	Management system			
	Extensive	Intensive	Semi-intensive	Tethering
Diarrhoea	6.55^{a}	6.27^{a}	6.98^{a}	6.52^{a}
Foot rot	5.90^{b}	4.91^{b}	4.37^{b}	6.00^{a}
Pneumonia	4.61^{c}	6.32^{a}	5.48^{a}	2.92^{c}
PPR	1.42^{e}	1.32^{e}	1.69^{d}	1.82^{cd}
Anthrax	1.63^{e}	2.05^{d}	1.52^{d}	1.72^{d}
Skin/ectoparasites	3.49^{d}	2.64^{c}	2.87^{c}	4.62^{b}
Helminthiasis	4.40^{c}	4.50^{b}	5.09^{a}	4.40^{b}
Kendall's W	0.88	0.86	0.92	0.80
P Value	0.001	0.0001	0.001	0.000

^{abc} *Means down columns with different superscript are significant at the Bonferroni adjusted significance level (Kendall's W test for non-parametric tests was used to compare mean ranks and means were separated using the Wilcoxon sign rank test, with a Bonferroni correction applied).*

The first point of call for farmers when they observed ill health within their flock, under the extensive system, was the use of ethnoveterinary remedies followed by the administration of drugs purchased by the farmer on the recommendation of other farmers. Professional veterinary technicians were only contacted as a third option if they were readily available (Table 9).

Table 9: Ranking of measures taken when farmers encounter disease

Action Taken	Extensive		Semi-intensive		Intensive		Tethering	
Veterinary technician	2.56^{b}	3rd	1.43^{a}	1st	1.18^{a}	1st	2.16^{b}	2nd
Community livestock worker	3.6^{c}	4th	3.85^{d}	4th	3.91^{d}	4th	4.00^{c}	4th
Medication by owner	2.28^{b}	2nd	1.93^{b}	2nd	1.82^{b}	2nd	2.24^{b}	3rd
Ethnoveterinary medicine	1.5^{a}	1st	2.79^{c}	3rd	3.09^{c}	3rd	1.60^{a}	1st

^{abc} *Means down columns with different superscript are significant at the Bonferroni adjusted significance level (Kendall's W test for non-parametric tests was used to compare mean ranks and means were separated using the Wilcoxon sign rank test, with a Bonferroni correction applied)*

All farmers practicing the intensive system dewormed their sheep, used ectoparasite control and used antibiotics. However, only 50% vaccinated against PPR. Majority (80.6%) of semi-intensive farmers dewormed their animals and vaccinated against PPR (67%), however, less than half (45%) of them used ectoparasite control. Farmers managing their sheep under the extensive system and tethering rarely used orthodox veterinary remedies provided by veterinary technicians, except for a small number (18%) of farmers practicing the extensive system who used antibiotics.

High prevalence of parasites, disease and associated mortalities are considered the most important constraints to sheep production in Ghana (Addah and Yakubu, 2008; Turkson, 2003; Turkson and Naandam, 2003). Mourad et al. (2001) reported that diarrhoea was the most important disease condition encountered in Djallonke sheep in Guinea, which often resulted in mortality of sheep, especially in lambs. Diarrhoea can be attributed to multiple causes ranging from nematode infestation (González-Garduño et al., 2021), to bacteria such as *E. coli* or poor nutritional management (Kusiluka et al., 1996). The prevalence in lambs is higher than in adult animals and causes higher rates of mortality in lambs compared to older animals in the flock (Mourad et al., 2001). Poor pen conditions may predispose sheep to respiratory infections (Koluman and Daskiran, 2011). Similarly, housing sheep on bare floor may expose them to worm infestation (Squire et al., 2019). The low ranking of scheduled diseases may reflect the timing of this survey since there was no outbreak of either PPR or Anthrax at the study sites.

The poor patronage of orthodox veterinary interventions under the extensive system and tethering may be a result of the inability of farmers to afford the cost of medication (Adams and Ohene-Yankyera, 2015). This poor investment in health care among farmers practicing the extensive system and tethering may account for sheep in those systems being more susceptible to disease infestation (Adams, 2015). The higher likelihood of disease stress in extensive sheep and those tethered, is likely to exacerbate poor nutrition and thereby impede growth and productivity of sheep (Agyemang et al., 1990).

Flock Productivity indices

Mortality rate

Farmers managing sheep under the extensive system reported the highest rate of mortality (32.7%) while sheep under intensive management had the lowest rate of mortality (14.9%) (Table 10). The mortality rate was significantly different across systems (χ^2=151, P<0.001) and sheep age classes (χ^2=292, P=0.000).

Table 10: Mortality rate by management system and age category

Variable	Percent mortality (%)	Chi-square	P-Value
Management system			
Extensive system	32.8^a (*n* = 1774)	151	<0.001
Intensive	14.9^b (*n* = 180)		
Semi-intensive	21.2^c (*n* = 1680)		
Tethering	28.5^a (*n* = 329)		
Age category			
Pre weaning (0 to 3 months)	40.4^a (*n* =1622)	292	<0.001
Post weaning to Yearling	34.9^b (*n* = 572)		
Adult	14.3^c (*n* = 1769)		

[abc]Means in the same column with common alphabet superscripts are not statistically different at the 95% level of probability

Mortalities represent a significant cause of poor productivity in livestock enterprises. Turkson (2003), reported a preweaning mortality rate of 33.5% for village flocks in the coastal savannah of Ghana, while Mourad et al. (2001) reported preweaning mortality rates of 30%. However, Turkson and Sualisu (2005), reported lower mortality rates for sheep managed under semi-intensive conditions at a government breeding station. This is indicative of the management system influencing the mortality rate. In this study, the high mortality rate of lambs across management systems and age groups (preweaning to adult) may be due to a variety of factors, including poor nutrition of the dam, poor health management and exposure to harsh environmental conditions. Farmers using the tethering method reported higher rates of abortions compared to the other management systems. This is likely a result of nutritional deficiencies in the dam. Amankwah et al. (2012), reported that farmers in the Upper East Region in northern Ghana associated tethering with high abortion rates and preweaning mortalities.

Reproductive performance of sheep

Lambing rate, age at first parturition and lambing intervals all differed significantly across management systems (P<0.001) (Table 11).

Table 11: Reproductive indices of sheep under different management systems

Parameter	Extensive	Semi-intensive	Intensive	Tethering	χ^2	P value
Lambing rate (%)	84.2^{b}	107.2^{a}	92.2^{b}	72.6^{c}	110.7	<0.001
Abortions (%)	6.5	3.4	0	19.8	36.57	<0.001
Age at first lambing (months)	14.9^{a}	12.9^{b}	11.8^{b}	15.8^{a}	-	<0.001
Lambing intervals (months)	9.8^{ab}	9.05^{b}	7.2^{c}	10.6^{a}	-	<0.001

[abc] *Means in the same row with different superscript alphabets are statistically different at the 95% level of probability.*

Reproduction is critical to the survival of species and environmental factors have a strong modulating influence on reproductive axis (Martin et al., 2004; Tec Canché et al., 2016; Narayan and Parisella, 2017). The ranges for age at first lambing and lambing intervals were within the estimate reported for the breed (Tuah and Baah, 1985; Salifu et al., 2018). The lambing rates fall within the ranges reported for Djallonke sheep according to Mourad et al. (2001), but were lower than lambing rates reported by Senou et al (2009) for the same breed raised on-station. The higher lambing rates observed for the different management systems may be due to plane of nutrition which increases the likelihood of twin births (Jainudeen et al., 2000).

The differences observed in reproductive performance may indicate differences in environmental factors such as level of feeding, health management, husbandry procedures and climatological factors. Sheep, especially dams and their lambs, reared under the Extensive system may be susceptible to nutrition stress since the quality of natural pasture particularly in the dry season is poor and no supplementary feed is offered. Sheep that are tethered similarly face constraints in obtaining adequate nutrition during the cropping season due to their limited movement. The high reproductive wastage in terms of abortions and preweaning mortalities is worth further investigation as no systematic study addresses reproductive wastage in northern Ghana. Abdul-Rahman and Rahim (2019) reported a significant effect of heat stress on physiological parameters of female sheep, however, no studies have been conducted on the effect of heat stress on the reproductive performance of this breed (Djallonke) given that reproduction is one of those functions adversely influenced by high temperatures. Temperature parameters were continuously measured in the farmers' production environment (Table 1) and the THI was found to be greater than 25, which is considered to be out the thermoneutral zone of sheep (Marai et al., 2007).

CONCLUSION AND RECOMMENDATIONS

Sheep were managed under four management systems, with the extensive system being the most popular. Most sheep relied on low quality uncultivated natural pasture, but intensive and semi-intensive sheep received feed supplementation. Most farmers under the semi-intensive and intensive systems provided housing for their sheep, but most sheep raised extensively were not housed. Temperature, humidity and THI showed that sheep may be exposed to heat stress, especially those managed under extensive system as well as tethering. Other potential stressors identified were nutrition stress, disease and heat stress mostly associated with extensive management systems.

In light of these findings, it is recommended that ameliorative measures such as improved feeding and provision of veterinary healthcare should especially be targeted at sheep raised in the extensive system and those tethered in the rainy season to improve their productivity.

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