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Effect of Flushing Hair Sheep Ewes During the Dry and Wet Seasons in the U.S. Virgin Islands

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Abstract: St. Croix White hair sheep ewes were used to evaluate the effect of supplemental nutrition prior to breeding during the dry and wet seasons on St. Croix. Beginning 21 d prior to breeding ewes were fed supplement in addition to grazing guineagrass pasture (FEED). Other ewes in the flock grazed pasture only (CONTROL). This study was conducted during the dry (June and July) and wet seasons (October and November). Data were analyzed by SAS using treatment and season as main effects. Days to estrus was greater ($P < 0.01$) in the dry than in the wet season (11.2 ± 1.3 vs 6.5 ± 1.3 d, respectively) but there was no difference ($P > 0.10$) in days to conception (11.6 ± 1.4 vs 9.2 ± 1.4 d, respectively). There was no effect ($P > 0.10$) of treatment or season on ovulation rate. Progesterone after estrus was higher ($P < 0.0001$) during the wet than the dry season (14.3 ± 0.4 vs 11.1 ± 0.4 ng/mL, respectively). The FEED ewes in the wet season gave birth to more lambs ($P < 0.03$) than FEED ewes in the dry season (2.2 ± 0.2 vs 1.6 ± 0.2 lambs, respectively) but there was no effect of season on the CONTROL ewes. Flushing of hair sheep ewes under tropical conditions does not appear to enhance ovulation rate during either the dry or wet seasons. The increase in the number of lambs born to ewes flushed during the wet season may be due to the natural occurrence of higher ovulations rates in ewes at that time of the year on St. Croix.

Key words: Sheep, ovulation, estrus, nutrition, tropics and forage

Introduction

The environment on St. Croix can be described as semi-arid with an average annual rainfall of 1098 mm (Godfrey and Hansen, 1996). The majority of the rainfall occurs during the months of September through December and during the months of January through August the rainfall is markedly less (Godfrey and Hansen, 1996). This leads to a seasonal pattern of forage availability. Livestock production in the U.S. Virgin Islands is based on a system that relies on forages and the rainfall and forage fluctuations throughout the year are of great concern to livestock producers.

Sheep in the Caribbean do not exhibit a seasonal pattern of reproductive cycles (Evans *et al.*, 1991; Swartz and Hunte, 1991). The intensive level of production, and year round breeding of the ewes requires that they have adequate nutrition during most of the year. Based on previous lambing data collected over 16 yr in our flock there is an increase in the number of lambs born when ewes are bred in the fall of the year compared to the summer (1.8 ± 0.03 vs 1.6 ± 0.03; Godfrey, unpublished data). This may be due to the increased level of forage available during the rainy season compared to the dry season of the summer months.

Providing supplemental nutrition to ewes prior to breeding, known as flushing, has been used in sheep to increase ovulation rate and embryo survival (Johnson *et al.*, 1990). This study was conducted to determine the effect of flushing hair sheep ewes grazing native pasture on ewe reproductive performance during the dry (low forage availability) and wet (high forage availability) seasons of the year.

Materials and Methods

St. Croix White hair sheep ewes that were bred in June and July (dry season) or October and November (rainy season) were used. The wet season evaluation period lasted from September 16, 1998 (first day of supplemental feeding) through November 11, 1998 (end of breeding) and the dry season evaluation period lasted from May 16 (first day of supplemental feeding) through July 11, 2001 (end of breeding). The long time between replications was due to the accelerated lambing system the ewes are managed under and the use of another ewe flock for other research project. All ewes were kept in eight guineagrass (*Panicum maximum*) pastures (.4 ha) throughout the duration of the project in a rotational grazing system with *ad libitum* access to water and mineralized salt. During the dry season the ewes grazed each pasture for 7 d and during the wet season ewes grazed each pasture for 21 to 27 d. At 3 wk prior to the start of breeding, ewes were assigned to treatment groups based on age, body weight (BW) and parity. Lactation status was also considered because the ewes were managed on an accelerated system to produce a lamb every 8 mo and as many as five ewes in each group were still nursing their lambs from the previous season when flushing started. All lambs were weaned prior to the start of the breeding period. Lactational anestrous was not a concern in this study because previous work in our laboratory (Godfrey *et al.*, 1998) has shown that the hair sheep ewes managed under the accelerated lambing system previously described have a postpartum interval to estrus of 39 to 44 days. Because breeding did not begin until all lambs were weaned (63 d of age) it was assumed that all ewes would be cycling by the time breeding started. The ewes had no contact with rams prior to the start of the 35-d breeding period.

In the dry and wet season one group of ewes (n = 13 and n = 13, respectively; FEED) was fed a pelleted sheep feed (PMI, Mulberry, FL) beginning 21 d prior to breeding and during the 35-d breeding period while grazing native pasture (Table 1). The amount of feed provided for ewes grazing tropical pasture was based on the guidelines put forth by Kawas and Huston (1990), and was determined individually for ewes within the FEED group based on BW measured weekly. This resulted in the ewes being fed 1.4 % of BW/d during the 21 d prior to and the duration of the 35-d breeding period. The standard practice for the sheep flock at the University of the Virgin Islands is to feed adult, non-lactating, non-pregnant ewes in confinement during the 35-d breeding period a maintenance ration of 2% of BW/d. The remaining ewes in the dry and wet seasons (n = 13 and n = 12, respectively; CONTROL) grazed guineagrass pasture only. Within season, both groups of ewes were kept in the same pastures during the study. The FEED ewes were sorted off in a drylot pen for the daily feeding (2 to 3 h/d). All FEED ewes were observed to consume the feed within the time period allotted each day. The CONTROL ewes were kept in an adjacent drylot pen during this time. Ewes were weighed weekly through the entire study.

During the wet season the ewes in each treatment were all bred to one St. Croix White ram. During the dry season seven ewes in each treatment were bred to a St. Croix White ram and six ewes were bred to a Dorper ram. The pasture was divided using a portable electric fence, 99 cm high, to separate the breeding groups during the dry season. Rams were equipped with marking harnesses to aid in detecting estrus. Day of estrus (d 0) was determined as the first day that marks were seen on the ewe form the ram harness or the ewe was observed to stand when mounted by the ram. Observations were conducted three times a day.

On day 7 after estrus, ovulation rate was determined in all ewes using a laparoscope with aseptic technique and a local anesthetic (Lidocaine). Ewes were placed in dorsal recumbency in a laparoscopy cradle for the procedure. After laparoscopy the incisions were closed with suture or surgical staples. Ewes were examined by transrectal ultrasound (Pie Medical Scanner 480 with 7.5 MHz linear transducer, Classic Medical Supply, Inc., Tequesta, FL) on day 24 to 40 after estrus to determine pregnancy. The day of conception was determined initially by non-return to estrus and then confirmed at lambing.

On day 8, 9 or 10 after estrus a jugular blood sample was collected from each ewe. Plasma was harvested and stored at -20°C until assayed for progesterone concentration by a commercial ELISA kit (OVUCHECK, Biovet Inc., Quebec, Canada) that had been previously validated in our laboratory (Godfrey *et al.*, 1997). Inter- and intra-assay CV were 5.7 and 10.1 %, respectively.

Herbage mass, an estimate of the total weight of forage per unit area of pasture, was measured at the start of the grazing period in each pasture. Six 0.5 m^2 plots randomly selected were harvested to a stubble height of 75 mm in each pasture and dried at 60 °C for 48 h to determine dry matter expressed as 1,000 kg per hectare (Mg/ha). Samples of forage and concentrate feed were sent to a commercial laboratory for nutrient analysis (Dairy One Cooperative, Inc., Ithaca, NY). Daily precipitation was recorded during each season of the study.

Data were analyzed using GLM Procedures of SAS (SAS Inst. Inc., Cary, NC). Feed and forage laboratory analysis results were analyzed using season as the main effect. Days to estrus, days to conception, ovulation rate, progesterone levels, number of lambs born and litter birth weight at subsequent lambing were compared within season (wet or dry) using the main effect of treatment, season and the interaction in the model. Weight ratio of ewes on days after the start of the study was calculated as the ratio of ewe BW to ewe BW at 21 d prior to breeding. Ewe BW ratio over time was analyzed using repeated measures procedures. Specifically,

Table 1: Composition of concentrate feed and guinegrass forage fed to hair sheep ewes

	Dry season[b]		Wet season[b]	
	Forage	Concentrate[c]	Forage	Concentrate[c]
Crude protein (%)	2.9 ± 0.4	16.3 ± 0.6	3.3 ± 0.1	19.0 ± 1.1
TDN (%)	17.0 ± 1.8	67.7 ± 2.9	18.1 ± 0.8	70.0 ± 5.1
ADF (%)	10.9 ± 1.5	21.2 ± 2.5	10.3 ± 0.3	11.7 ± 4.4
NDF (%)	17.2 ± 2.2	30.6 ± 3.7	18.0 ± 1.1	22.9 ± 6.4
NE_m (Mcal/kg)	0.16 ± 0.02[d]	0.74 ± 0.03	0.36 ± 0.02[e]	0.79 ± 0.05
NE_g (Mcal/kg)	0.09 ± 0.01[d]	0.48 ± 0.02	0.20 ± 0.02[e]	0.54 ± 0.03
NE_l (Mcal/kg)	0.14 ± 0.02[d]	0.72 ± 0.03	0.34 ± 0.04[e]	0.75 ± 0.05
Dry matter (%)	29.7 ± 2.0	88.8 ± 4.9	28.7 ± 3.3	89.2 ± 8.6
Total green forage (Mg/ha)	4.1 ± 0.7[f]	14.5 ± 1.1[g]		
Forage dry matter (Mg/ha)	0.9 ± 0.2[f]	3.9 ± 0.3[g]		

[a]Values for crude protein, TDN, ADF, NDF, NE_m, NE_g and NE_l are reported on as-fed basis. The Feed ewes were provided with a pelleted feed for 21 d prior to and 35 d during breeding and the Control ewes grazed guineagrass pasture only.
[b]The wet season evaluation period lasted from September 16, 1998 (first day of supplemental feeding) through November 11, 1998 (end of breeding) and the dry season evaluation period lasted from May 16 (first day of supplemental feeding) through July 11, 2001 (end of breeding).
[c]Feed ingredients as listed on the feed tag from the manufacturer were ground corn, , alfalfa meal, cottonseed meal, ground peanut hulls, wheat middlings, soybean meal, ammonium chloride, cane molasses, bentonite, vitamin A, dicalcium phosphate, salt, sodium selenite, sodium molybdate, calcium iodate, ferrous carbonate, manganous oxide, cobalt carbonate, calcium carbonate, and zinc oxide.
[d,e]Values within a row and feed type with different superscripts are different ($P < 0.01$).
[f,g]Values within a row and feed type with different superscripts are different ($P < 0.0001$).

Table 2: Body weight (kg) of hair sheep ewes bred during the dry or wet season on St. Croix while

	Dry season		Wet season	
Body weight on day[a]	Control	Feed	Control	Feed
-21	38.7±0.4	38.7±0.4	38.8±0.4	39.3±0.4
0	39.8±0.4	40.5±0.4	36.7±0.4[b]	39.5±0.4[c]
35	42.7±0.4d	43.8±0.4[e]	38.2±0.4[b]	41.4±0.4[c]

[a]Day −21 is when flushing started, d 0 is when breeding started, d 35 is the end of breeding.
[b,c]Values with different superscripts within season are different ($P < 0.0001$).
[d,e]Values with different superscripts within season are different ($P < 0.02$).

Table 3: Reproductive performance of hair sheep ewes bred during the dry or wet season on St.

	Dry season		Wet season	
	Control	Fed	Control	Feed
Time to estrus (d)	11.3 ± 1.8[c]	11.2 ± 1.8[c]	6.1 ± 1.8[d]	6.8 ± 1.7[d]
Time to conception (d)	11.3 ± 2.1	11.9 ± 1.9	10.3 ± 2.0	8.1 ± 1.9
Ovulation number	1.9 ± 0.2	2.0 ± .02	2.1 ± 0.2	2.0 ± 0.2
Progesterone after estrus[a] (ng/mL)	10.9 ± 0.5[c]	11.3 ± 0.5[c]	15.1 ± 0.5[d,e]	13.4 ± 0.5[d,f]
Number of lambs born[b]	2.0 ± 0.1	1.6 ± 0.2[g]	1.8 ± 0.2	2.2 ± 0.2[h]
Litter birth weight (kg[b])	5.9 ± 0.5	5.2 ± 0.5	5.2 ± 0.6	5.6 ± 0.5

[a]Measured in a blood sample collected between 8 to10 d after estrus.
[b]Refers to number of lambs born at the subsequent lambing period.
[c,d]Values within a treatment with different superscripts are different ($P < 0.01$).
[e,f]Values within a season with different superscripts are different ($P < 0.03$).
[g,h]Values within a treatment with different superscripts are different ($P < 0.03$).

ANOVA consistent with a split-plot experimental design was utilized. Terms included in the whole plot were treatment and season and the treatment x season interaction. The error term was ewe within treatment x season. Factors included in the sub-plot were days after feedings started feeding as a measure of time, along with the appropriate interactions with season and treatment, using the residual as the error term.

Mean separation, or pre-planned comparisons, was conducted using the PDIFF option. All values are reported as least squares means and standard errors.

Results

The total accumulation of rainfall for the entire year in which the study was conducted during the dry season was 1325 mm, and 1370 mm for the year in which the study was conducted during the wet season. The rainfall data for 90 d prior to the start of the feeding treatment through the end of the 35-d breeding period for the dry and wet season of the year is shown in Fig. 1. The total accumulation of rainfall for the portion of the study conducted during the dry season was 421 mm (Fig. 1a), and 741 mm for the portion conducted during the wet season (Fig. 1b).

Results of the laboratory analysis of the feed and forage samples are presented in Table 1. The nutritional content of the concentrate feed was similar between the dry and wet seasons. The forage had higher ($P < 0.01$) energy content during the wet season than during the dry season. The amount of total forage and forage dry matter available in the pastures was higher ($P < 0.0001$) during the wet season than the dry season.

There was no difference ($P > 0.10$) in ewe BW at 21 d prior to the start of flushing between season or treatment group (Table 2). The FEED ewes were heavier ($P < 0.0001$) than CONTROL ewes during the wet season on d 0 (start of breeding) and 35 (end of breeding) and on d 35 during the dry season ($P < 0.02$). During the dry season both groups of ewes gained approximately 5 % of their initial weight during the 21 d prior to breeding and continued to gain weight during the 35-d breeding period, but the FEED ewes gained more weight ($P < 0.0001$) than the CONTROL ewes (Fig. 2a). During the wet season the FEED ewes maintained their weight while the CONTROL ewes lost approximately 5 % of their weight in the 21 d prior to the start of breeding and the FEED ewes continued to gain weight during the breeding period while the CONTROL ewes lost weight ($P <$

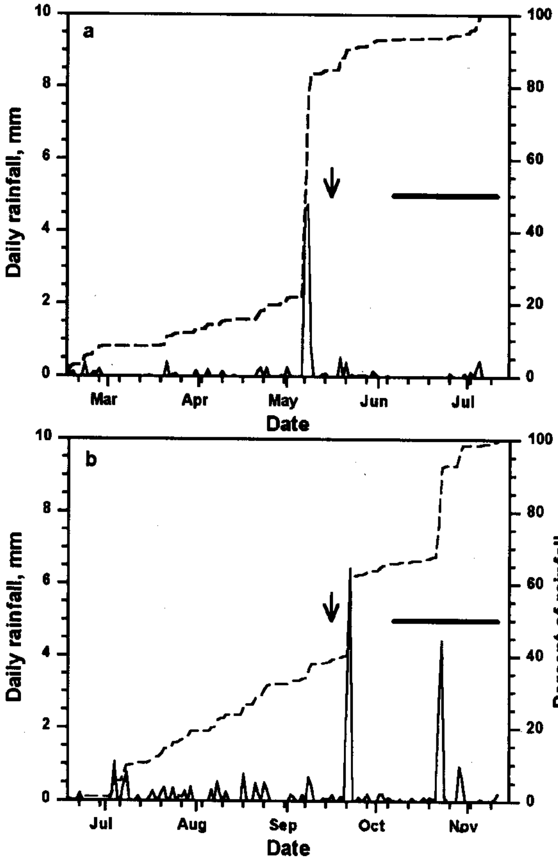

Fig. 1: The daily rainfall (solid line) and percent of total rainfall (dashed line) during the dry (a) and wet (b) seasons on St Croix is shown. The arrow indicates when flushing began and continued through the 35-d breeding period (black bar).

0.0008; Fig. 2b).

The time to estrus after the start of the breeding period was shorter ($P < 0.01$) during the wet season than in the dry season (6.5 ± 1.3 vs 11.2 ± 1.3 d, respectively) but there was no effect ($P > 0.10$) of treatment within a season (Table 3). There was no effect ($P > 01.0$) of treatment or season on the time to conception after the start of breeding or on ovulation rate (Table 3). Progesterone levels at 7 to 12 d after estrus were higher ($P < 0.0001$) during the wet season than during the dry season (14.3 ± 0.4 vs 11.1 ± 0.4 ng/mL, respectively). During the wet season progesterone levels were higher ($P < 0.03$) in the CONTROL ewes than in the FEED

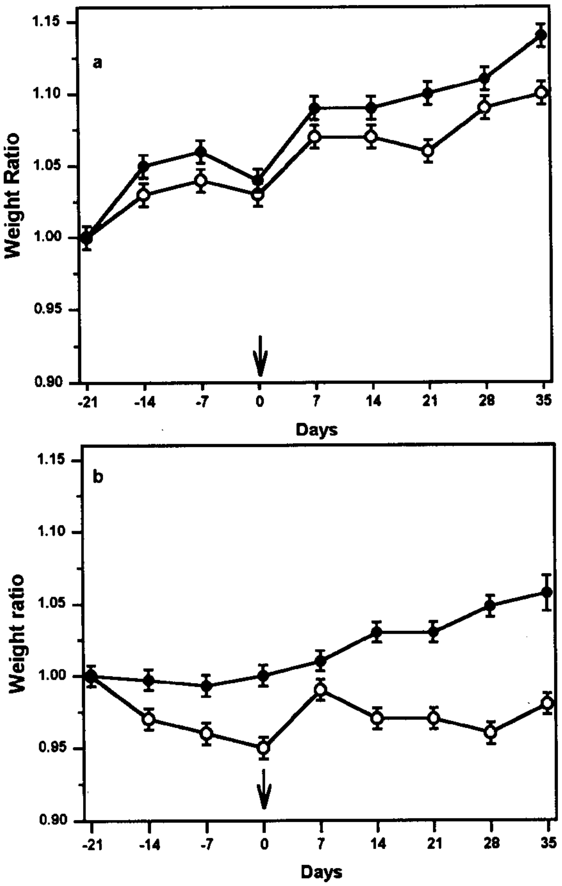

Fig. 2: The relative weight change of the CONTROL (open circles) and FEED ewes (solid circles) during the dry (a) and wet (b) seasons is shown. Weight ratio was calculated as the ratio of ewe BW on a given day to ewe BW at 21 d prior to breeding. The FEED ewes were fed concentrate for 21 d prior to and during the 35-d breeding period and the CONTROL ewes grazed guineagrass pasture only during this time. The arrow indicates when the breeding period began. During the dry season both groups gained weight but the CONTROL ewes had a smaller increase in weight than FEED ewes ($P < 0.0001$). During the wet season the FEED ewes gained weight and the CONTROL ewes maintained weight ($P < 0.0008$).

ewes but there was no difference between treatments during the dry season (Table 3).

The number of lambs born at the subsequent lambing was higher ($P < 0.03$) in FEED ewes during the wet season than during the dry season (Table 3). There was no difference ($P > 0.10$) in the number of lambs born to CONTROL ewes between the seasons. The litter weight of lambs was not affected ($P > 0.10$) by either treatment or season (Table 3).

Discussion

The total rainfall for the year in which the study was conducted during the dry season was 1325 mm, and 1370 mm for the year in which the study was conducted during the wet season. Both of these are above the average annual rainfall of 1098 mm reported previously (Godfrey and Hansen, 1996). Even though the rainfall for the portion of the study conducted during the dry season (421 mm) was lower than the rainfall for the portion conducted during the wet season (741 mm) there may have been some residual effects of the greater than average annual rainfall that carried through the rest of the year. There were differences in the amounts of forage and dry matter in the pastures between seasons but the percentage dry matter was similar which may have been due to the amount of rain received during the entire year. During the dry season, 80 % of the seasonal rainfall had accumulated by the start of the study but during the wet season only 40 % of the seasonal rainfall had accumulated by the start of the study.

The two ewe flocks at University of the Virgin Islands are extensively managed under an accelerated lambing system, on guinegrass pastures, in which each flock produces a lamb crop every 8 mo. Lambs are weaned at 63 d of age, which allows for at least a 1- to 2-wk period before breeding resumes. West *et al.* (1991) reported that ewes maintained in good body condition throughout the year are able to perform at or near their production potential. Ewe body condition was not evaluated in the present study, but based on previous breeding periods during the past 8 yr, the ewes tend to be in moderate body condition at the start of breeding (Godfrey, unpublished data). The weight gain by both groups of ewes during the dry season breeding period is in contrast to the maintenance or loss of weight seen during the wet season. During the wet season grasses are in a stage of rapid growth and ewes may not be able to consume enough grass to meet their nutritional requirements. Johnson *et al.* (1990) noted that rapidly growing tropical grasses contain high levels of cell wall fiber that is poorly digested in the rumen and the energy available from such forages is limited along with the ewe's rumen capacity for feed with such high fiber content. In the present study there was no difference in moisture content of the forage between the seasons, so limited intake due to high moisture content may not have played a role in the weight loss of the CONTROL ewes during the wet season.

Flushing has been used successfully in sheep to increase ovulation rate and embryo survival (Johnson *et al.*, 1990) but has been reported to be only partially successful in enhancing reproductive performance of ewes in poor condition (West *et al.*, 1991). Wildeus *et al.* (1989) reported that hair sheep ewes that were flushed for four weeks prior to breeding had an increase in body weight and exhibited estrus earlier in the breeding season than ewes that were not flushed but there was no effect of the flushing on ovulation rate or lambing rate. The authors hypothesized that the ewes may have been in poor body condition at the start of flushing because they were still nursing lambs, and were unable to respond to the flushing (Wildeus *et al.*, 1989). In the present study there were some ewes still nursing lambs at the time flushing started, but the majority of ewes in each group in each season had already had their lambs weaned. The lack of difference in time to estrus between the flushed and control ewes in the present study is in contrast to the results of Wildeus *et al.* (1989). It is unclear why this occurred, especially in light of the fact that during the dry season ewes gained weight and during the wet season ewes maintained or lost weight. The results of the present study are in contrast to those of Molle *et al.* (1995) who flushed ewes for 2 weeks prior to and 3 weeks after ram introduction and observed an increase in ovulation rate and number of lambs born per ewe. Based on 16 yr of lambing data for these ewes the number of lambs born to ewes bred in the fall is higher than in ewes bred in the summer (Godfrey, unpublished data). This increase in lamb number may be due to the increased forage availability during the fall rainy season compared to the dry summer months. This naturally occurring increase in ovulation number does not appear to be enhanced with supplemental feed. In addition, the ewe flocks in the present study have been selected for twinning over the past 16 years and this may have minimized the influence of flushing during the dry season the ovulation rate and lamb number produced.

Parr *et al.* (1993) reported that feed intake increased the metabolic clearance rate of progesterone but the secretion rate of the corpus luteum was unable to change to match the clearance rate. This may explain the higher progesterone concentrations after estrus in CONTROL compared to FEED ewes during the wet season. The higher progesterone concentrations during the wet season compared to the dry season may be related to the time of year. Progesterone levels through d 63 postpartum were shown to be higher in the fall than in the summer by Godfrey *et al.* (1998) and were thought to reflect a response to the slight change in photoperiod on St. Croix. The data from the present study was collected during the same times of the year as that of Godfrey *et al.* (1998) and the seasonal effect may explain why progesterone concentrations were higher during the wet season compared to the dry season.

During the dry and wet season on St. Croix, it is hypothesized that the ewes were able to obtain adequate nutrition from the available forage to achieve ovulation rates, fertility and lamb numbers that were similar regardless of receiving supplemental feed. The supplemental nutrition provided to the hair sheep ewes does not appear necessary to maintain a high level of ewe reproductive performance at either time of the year under tropical conditions. Without a production or economic incentive there is no need for hair sheep producers in the U.S. Virgin Islands to incur the extra cost of supplemental feed.

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