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Evaluation of Split Feeding Regimens on Growth and Productivity of Hair Sheep Ewes and Lambs in the Tropics

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Abstract: Hair sheep ewes and lambs were used to evaluate the impact of feeding a split ration on productivity and growth. St., Croix White, Barbados Blackbelly and Barbados Blackbelly x St., Croix White lambs weaned at 63 days of age were group fed for 100 days beginning at 2 weeks after weaning. Treatments consisted of feeding concentrate (16% CP, 68% TDN) in the morning (am; n = 19), afternoon (pm; n = 19) or split between the morning and afternoon (am to pm); n = 18) at 4% of BW/(lamb·day). In a second study lactating St. Croix White and Dorper x St., Croix White ewes grazing guinea grass pastures were assigned to treatments (n = 16/treatment) based on breed, age and number of lambs. Treatments consisted of individually feeding ewes 0.9 kg concentrate (16% CP, 68% TDN) in the morning (am) or afternoon (pm), 0.45 kg in the morning and afternoon (am to pm) or no feed (Control) beginning on day 7 (lambing = day 0). On day 21, 24 h milk production was measured. A sterile ram with a marking harness was used to detect estrus. The am and pm lambs gained less ($p<0.02$) than the am to pm lambs (10.3±0.8 ks. 10.2±0.8 vs. 12.1±0.8 kg, respectively). The am to pm lambs had higher ($p<0.0004$) ADG than either the am or pm lambs (138.1±13.1 vs. 110.4±12.9 vs. 111.5±13.1 g day^{-1}, respectively). The am to pm ewes consumed a higher ($p<0.0001$) percentage of their feed than am or pm ewes (98.4±1.9 Vs. 91.5±1.9 Vs. 92.9±1.9 %, respectively). Post-partum interval to estrus was shorter ($p<0.02$) in am to pm ewes than in pm ewes (39.6±3.9 vs. 42.9±1.3 vs. 44.2±3.9 day, respectively). Milk production and litter weaning weight were not different among treatments ($p>0.10$). Weight loss by control ewes was greater ($p<0.002$) than the am, pm or am to pm ewes (4.4±1.4 vs. 0.9±1.4 vs. 1.2±1.4 vs. 0.06±1.4 kg, respectively). Lambing rate at the subsequent lambing period was not different among treatments ($p>0.10$). A split feeding regimen increased feed consumption and decreased post-partum weight loss but did not increase litter weaning weight or milk production of hair sheep ewes. It does not appear beneficial to feed hair sheep ewes during the post-partum period using either a once a day or a split feeding regimen. A split feeding regimen increased weight gain and ADG of weaned hair sheep lambs and it may be an option to utilize this management practice to increase gain if the economics of the added labor for twice a day feeding are feasible.

Key words: Ewes, feeding, hair sheep, lambs, post-partum, tropics

INTRODUCTION

Sheep in the Caribbean consist of hair breeds that produce relatively small lambs with light carcass weights at slaughter. By crossbreeding local sheep with a heavy muscled breed such as Dorper, it is possible to increase ADG of weaned lambs fed a forage or concentrate diet (Dodson *et al*., 2005; Godfrey and Weis, 2005). Even with the use of crossbreeding to increase growth of lambs, extensive use of concentrate feed for growing and finishing lambs in the US Virgin Islands is not economical due to the high feed cost (Godfrey and Collins, 1999; Godfrey and Weis, 2005).

Feeding livestock multiple times a day is a common practice, especially in feedlots (Millen *et al*., 2009). Church and Ralston (1963) reported that steers fed twice a day had lower ADG and feed intake than steers with *ad libitum* access to feed and suggested that adaptation to the feeding stations played a role in limiting gain and feed intake. It has been reported that feeding lambs more frequently than twice a day did not increase ADG or feed conversion (Rhodes and Woods, 1962; Prior, 1976). Feeding lactating ewes once a day has been shown to increase milk production, lamb weaning weight and ADG during the dry season, decrease post-partum interval during the wet season and decrease ewe weight loss during both seasons (Godfrey and Dodson, 2003). Robles *et al.* (2007) suggested that feeding twice daily could be a practical way to better control the daily pH fall resulting in more stable ruminal conditions in cattle.

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Most of these studies have been conducted under temperate conditions with temperate breeds and very little has been done with small ruminants in the tropics. Using a split ration to enhance lamb weight gain and ewe productivity in the tropics has not been studied extensively. Researchers designed two experiments to evaluate the influence of time of feeding concentrate to weaned lambs on weight gain and the influence of time of day of feeding concentrate to lactating ewes on weight change and production traits.

MATERIALS AND METHODS

The sheep were managed in accordance with the Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching (FASS, 1999) and experimental procedures were approved by the University of the Virgin Islands Animal Care and Use Committee.

Lamb feeding trial: St., Croix White, Barbados Blackbelly and Barbados Blackbelly x St., Croix White lambs weaned at 63 days of age in May, 2006 or January, 2007 were used. Within each year lambs were distributed uniformly across treatments at weaning based on breed, gender and number of lambs in litter (Table 1). Lambs were fed a pelleted concentrate diet (16% CP, 68% TDN, 22% ADF, 32% NDF as fed; PMI, Mulberry, FL) at maintenance levels (2% of BW/(lamb·day)) for 2 weeks after weaning to get them accustomed to the feed. At 1 week after weaning ram lambs were castrated using a surgical procedure. Beginning at 2 weeks after weaning lambs were sorted into groups of 4-5 lambs and placed in the feeding pens (3.2×6.8 m) with 30% shaded area. Treatments consisted of feeding the concentrate diet in the morning (am), afternoon (pm) or split equally between the morning and afternoon (am to pm) at the rate 4% of BW/(lamb.day) for 100 days (Table 1). Lambs consumed all of the feed offered to them at each feeding so there were no orts to weigh and intake was recorded as 100% for each pen. Each treatment was replicated 2 times (2 feeding pens) within each lamb crop using 4-5 lambs per pen. Lambs had *ad libitum* access to mineralized salt blocks, guinea grass hay, provided so as not to be limiting consumption and water while in the pens. Lambs were weighed each week and the amount of concentrate offered was adjusted accordingly.

Table 1: Distribution of lambs among breedtypes and treatments[1]

Distribution	Weaning group May, 2006	 January, 2007
Breedtype		
Barbados Blackbelly	11	25
Barbados Blackbelly x St., Croix White	5	0
St., Croix White	14	1
Treatment		
am	10	9
am to pm	10	8
pm	10	9

[1]Lambs were group fed a concentrate diet at 4% BW/(lamb.day) in the morning (am), afternoon (pm) or split between the morning and afternoon (am to pm)

Lamb weight data included initial and final BW, total gain and ADG. Individual feed intake and feed efficiency could not be determined because animals were group fed.

Ewe feeding trial: Ewes were managed in an accelerated lambing system to produce a lamb crop every 8 mo., Multiparous, lactating St., Croix White (n = 16) and Dorper x St., Croix White (n = 16) ewes that lambed in July, 2005 or March, 2006 were maintained on guinea grass (*Panicum maxiumum*) pastures in a rotational grazing system throughout the data collection period each year. Ewes were rotated through a set of 0.8 ha paddocks so that forage availability was never limited. Ewes were assigned to treatments (n = 8/treatment) each year at lambing (day 0) based on breed, ewe age and number of lambs born. Treatments consisted of individually feeding ewes 0.9 kg concentrate (16% CP, 68% TDN, 22% ADF, 32% NDF as fed; PMI, Mulberry, FL) in the morning (am) or afternoon (pm), 0.45 kg in the morning and afternoon (am to pm) or no feed (Control) beginning on day 7 and continuing through day 63 when lambs were weaned. Ewes were managed as one flock and housed in the same set of pastures. The fed ewes were sorted off in the morning (08:30-09:30 h) or late afternoon (15:30-16:30 h) for their feeding. The control, am and pm ewes not receiving feed were sorted off into a pen with no feed for the duration of the am or pm feeding each day. The am, am to pm and pm ewes were fed individually using pen dividers with individual feed containers and orts were weighed after each feeding. Lambs were separated from all ewes including the control ewes during the feeding periods. The ewes stayed in the feeding pens until the feed was consumed or for >30 min after sorting which ever came first. After feeding all ewes were returned to the pasture.

Two sterile rams equipped with marking harnesses were placed with the ewes beginning at 14 days after the first ewe lambed to monitor return to estrus. Ewes were checked for marks twice daily at the sorting and feeding times. Post Partum Interval (PPI) was determined as the 1st day that crayon marks from the ram were observed on a ewe. Ewe milk production was measured on day 21 using procedures before described (Godfrey *et al*., 1997). On the days of milking, lambs were separated from ewes after the morning feeding and placed in a holding pen with access to shade and water. The ewes were given 1 IU of oxytocin (i.v.) and milked by hand. About 4 h later, the ewes were milked again after a second injection of 1 IU oxytocin (i.v.). This milk was weighed and adjusted to 24 h milk production. Lambs were returned to the ewes at this time. Ewes were weighed each week through day 63 and lambs were weighed at birth and at weaning (63 days of age).

Ewe weight data included initial and final BW, weight change expressed in kg and as a percentage of initial BW and feed intake expressed as a percentage of total feed offered. Ewe production data included PPI, 24 h milk production at 21 days of lactation, ewe weight at weaning, litter weight at weaning, ewe efficiency, lambing rate at subsequent lambing and day of lambing at subsequent lambing. Ewe efficiency, expressed as a percent was calculated by dividing litter weaning weight by ewe BW at weaning.

Data analysis: Lamb and ewe data were analyzed using PROC MIXED procedures of SAS (SAS Inst. Inc., Cary, NC). Lamb weights and ADG were analyzed using feeding regimen and gender as the main effects with lamb, breed and replicate as random effects. Researchers have previously reported that ADG of indigenous hair sheep lambs was not different among breeds so breed was not considered as a main effect in the analysis (Godfrey *et al*., 1997). As stated before, individual feed intake and feed efficiency could not be determined because animals were group fed. Because the feed intake of lambs was 100% for each pen it was not analyzed.

Ewe weights, weight change, feed intake, PPI, milk production, efficiency, litter size, litter weaning weight and day of lambing were analyzed using feeding regimen as the main effect with ewe, breed and year as random effects. Lambing rate of ewes was analyzed using the CATMOD procedure of SAS. In lambs and ewes, the effect of year and replicate was not significant and all data were pooled across years and replicates for the final analysis. Results are reported as least squares means±SEM and separated using PDIFF option.

RESULTS AND DISCUSSION

Lamb feeding trial: There was no difference (p>0.10) in initial or final BW of lambs among treatments (Table 2). Lambs in the am to pm group had a greater total weight gain (p<0.02) and ADG (p<0.0004) than either the am or pm lambs (Table 2). Wether lambs had higher initial BW (p<0.03), final BW (p<0.005), total weight gain (p<0.02) and ADG (p<0.003) than ewe lambs (Table 3).

Ewe feeding trial: There was no difference (p>0.10) in the initial weight of ewes among treatments but the ewes fed the split ration (am to pm) had a higher (p<0.04) final

Table 2: Growth traits of lambs fed in the morning (am), afternoon (pm) or a split ration (am to pm)[1]

Treatments	Initial BW (kg)	Final BW (kg)	Total gain (kg)	ADG (g day^{-1})
am	12.6±0.7	23.1±0.9	10.3±0.5^{a}	105.4±5.1^{c}
pm	12.5±0.8	22.6±0.9	10.2±0.5^{a}	105.9±4.9^{c}
am to pm	12.7±0.7	24.7±0.9	12.1±0.5^{b}	131.1±5.1^{d}

[1]Lambs were group fed a concentrate diet at 4% BW/(lamb.day); Means within columns without a common superscript differ (^{a,b}p<0.02; ^{c,d}p<0.0008)

Table 3: Growth traits of ewe and wether lambs pooled across feeding groups[1]

Gender	Initial BW (kg)	Final BW (kg)	Total gain (kg)	ADG (g day^{-1})
Ewes	11.6±0.6^{a}	21.9±0.7^{c}	10.2±0.4^{e}	104.2±4.2^{g}
Wethers	13.5±0.6^{b}	25.1±0.7^{d}	11.5±0.4^{f}	124.1±4.0^{h}

[1]Lambs were group fed a concentrate diet at 4% BW/(lamb·day) in the morning, afternoon or split between the morning and afternoon. Means within columns without a common superscript differ (^{a,b}p<0.03; ^{c,d}p<0.005; ^{e,f}p<0.02; ^{g,h}p<0.001)

Table 4: Production traits of ewes fed in the morning (a.m), afternoon (pm) or a split ration (am to pm) during lacattion1

	Treatments			
Traits	Control	a.m	pm	am to pm
Initial BW (kg)	46.9±1.7	46.7±1.8	49.1±1.7	50.30±1.8
Final BW (kg)	42.6±1.7^{a}	45.8±1.7^{a,b}	47.8±1.7^{a,b}	50.40±1.7^{b}
Weight loss (kg)	4.4±0.7^{c}	0.9±0.7^{d}	1.2±0.7^{d}	0.05±0.7^{d}
Weight loss[2] (%)	9.3±1.4^{c}	1.9±1.4^{d}	2.8±1.4^{d}	0.80±1.4^{d}
Feed intake (%)	-	91.3±0.5^{e,g}	92.9±0.5^{f,g}	98.30±0.3^{h}

[1]Ewes were individually fed 0.9 kg day^{-1} of a concentrate diet in one feeding or split over two feedings. Control ewes received no concentrate; [2]Determined as a percentage of initial BW; Values within rows without a common superscript differ (^{a,b}p<0.03; ^{c,d}p<0.002; ^{e,f}p<0.01; ^{g,h}p<0.0001)

weight than control ewes with the am and pm fed ewes being intermediate (Table 4). The control ewes lost more weight during lactation (p<0.002) than the am, pm or am to pm fed ewes expressed as either an absolute amount (kg) or a as percentage of initial BW (Table 4). The am to pm ewes consumed a larger proportion of the feed offered to them (p<0.0001) than either the am or pm fed ewes and the ewes in the pm group consumed a higher proportion of their feed (p<0.03) than did the ewes in the am group (Table 4). Ewes in the am to pm group had a shorter PPI than the PM ewes (p<0.02) with the control and am ewes being intermediate (Table 5). The am to pm ewes were heavier (p<0.04) than the control and am ewes at weaning with the PM ewes being intermediate (Table 5). Lambing rate and day of lambing at the subsequent lambing were not different (p>0.10) among treatments (Table 5). Milk production at day 21 post-partum was not different (p>0.10) among treatments (Table 5). Litter weaning weight, litter size and ewe efficiency were not different (p>0.10) among treatments (Table 5).

The use of the am feeding as the control group for the lamb feeding trial reflects a common practice of

Table 5: Production traits of ewes fed in the morning (am), afternoon (pm) or a split ration (a.m to p.m) during lacattion[1]

	Treatment			
Traits	Control	am	pm	am to pm
Post-partum interval (day)	40.4±1.3^{a,b}	42.9±1.3^{a}	44.6±1.6^{a}	38.8±1.4^{b}
Milk[2] (g)	1257±178	1315±184	1518±178	1459±188
Ewe wt at weaning[3] (kg)	42.1±1.7^{a}	43.2±1.7^{a}	46.5±1.7^{a,b}	48.3±1.7^{b}
Litter weaning weight[3] (kg)	19.8±1.5	22.9±1.5	24.1±1.5	23.1±1.5
Ewe efficiency[4] (%)	47.7±3.9	54.2±3.9	53.5±3.9	47.5±3.9
Lambing rate (%)	100	86.7	100	93.8
Day of lambing	8.8±0.8	12.0± 1.8	11.6±1.7	11.8±1.7

[1]Ewes were individually fed 0.9 kg day^{-1} of a concentrate diet in one feeding or split over two feedings. Control ewes received no concentrate; [2]Measured using oxytocin and 4 h lamb removal on day 21 of lactation; [3]Lambs were weaned at 63 days of age; [4]Caluclated as (litter weaning weight/ewe BW at weaning) x 100; Values within rows without a common superscript differ ($^{a,b}p<0.04$)

feeding lab, feeding hair sheep lambs with concentrate results in growth rates that are higher than those of lambs grazing forage only (Godfrey and Collins, 1999; Dodson *et al*., 2005; Godfrey and Weis, 2005). The ADG of the am to pm fed lambs in the present study (138 g day^{-1}) is similar to the ADG of St., Croix White lambs fed green chopped guinea grass and a coconut meal supplement (133 g day^{-1}) in a study by Hammond and Wildeus (1993). The coconut meal and guinea grass were reported to have CP contents of 23 and 6%, respectively. Based on amounts fed in the current study, the lambs received approximately 30% less CP day^{-1} than lambs in the study by Hammond and Wildeus (1993), yet the am to pm fed lambs were able to achieve similar ADG. The ADG of the am to pm lambs in the current study is also similar to that of Dorper x St., Croix White lambs reported previously (Godfrey and Weis, 2005). The increased ADG of the am to pm lambs indicates that it may be possible to achieve rates of gain similar to Dorper crossbred lambs by utilizing a split feeding regime for local breeds of hair sheep. Lambs in both studies were fed similar diets and the only differences were the breeds used and the split feeding protocol.

The total weight gain of the St., Croix White and Dorper crossbred lambs in a previous study (Godfrey and Weis, 2005) is greater than that reported in the present study. This may be due in part to the fact that lambs in the present study were fed for 100 days with final weights <25 kg and the lambs in the previous study (Godfrey and Weis, 2005) were on feed until they reached a target weight of 30 kg which took between 120-150 days. In another study by Godfrey and Collins (1999) St., Croix White and Suffolk x St., Croix White lambs were fed concentrate at 4% BW once a day for 100 days and had ADG of 144 and 160 g day^{-1}, respectively. Both of these values are higher than those for any group in the current study but could be explained partially by the breeds used and the hay fed (guinea grass vs. coastal bermudagrass).

Lactating ewes require increased levels of nutrients and would be susceptible to undernutrition during periods of low forage quality or quantity (Johnson *et al*., 1990). The weight loss of all ewes during lactation was expected and previous research has shown that feeding ewes during this time cannot prevent the weight loss but it can decrease the magnitude of weight lost (Godfrey and Dodson, 2003). Even with supplemental nutrition the native forage is not sufficient to prevent weight loss in lactating ewes. The predominant grass in the pastures, guineagrass has a reported CP content of 8% (on a DM basis) which is adequate for maintenance but may not be sufficient for lactating ewes. The legume leucaena (*Leucaena leucocephala*) has been reported to have a CP content of 28% but based on subjective evaluation, it accounted for <20% of the forage available in the pastures.

The higher level of feed consumption of the am to pm ewes may be related to the lower weight loss they experienced. The ewes that received feed lost <3% of their initial weight but the control ewes lost >9% of their BW during the same time period. This is much lower than the 20-25% relative weight loss during lactation reported by Godfrey and Dodson (2003). The amount of feed received by ewes in the current study was approximately 2% BW/(ewe·day) and in the previous study (Godfrey and Dodson, 2003) ewes were fed 2.3% BW/(ewe.day) during the last 14 days of gestation and 3.8% BW/(ewe·day) during the 1st 21 days of lactation. This difference in the number of days that ewes were fed during lactation, 35 days in the previous study and 63 days in the current study may also contribute to the difference in relative weight loss observed between the studies.

Wildeus reported that dams of creep-fed lambs exhibited a tendency to have a shorter post-partum interval to estrus. In a previous study, the PPI of ewes receiving supplemental feed during late gestation (14 days prior to lambing; 2.3 % BW/(ewe.day)) and the 1st 21 days of lactation (3.8% BW/(ewe.day)) was 8 days shorter than that of ewes grazing guinea grass only during the wet season (Godfrey and Dodson, 2003). This difference is slightly >5 days difference between am to pm and pm ewes in the present study. This decrease in PPI in the present study was not reflected in the day of lambing at the subsequent lambing season. It is possible that because of the length of the PPI a majority of the ewes are cycling before the breeding season starts. This is further evidenced by a study that reports the PPI of hair sheep managed in an accelerated lambing system is not influenced by exposure to the ram during the post-partum period or season of the year with an average of 42 days (Godfrey *et al*., 1998). In the accelerated lambing system used to manage the flock ewes are not exposed to the ram until after weaning at 63 days post-partum so shortening the PPI may not be of much benefit under this system.

The values for milk production presented are similar to those reported previously for hair sheep in the tropics (Godfrey *et al*., 1997; Godfrey and Dodson, 2003) and a temperate wool breed (Muir *et al*., 1993) but lower than levels for other temperate wool breeds (Knight *et al*., 1993a, b). Godfrey and Dodson (2003) reported that it is possible to increase milk production on day 21 post-partum with supplemental feed during the dry season. Jaime and Purroy (1995) reported that ewes provided with 110% of CP requirements during lactation produced more milk than ewes receiving 90% of CP requirements. The ewes in the present study were fed concentrate ration that provided <75% of their nutritional requirements during lactation based on the data of Kawas and Huston (1990). The nutritional composition of the forage was not measured but previously we have reported that the guinea grass pastures grazed by the University of the Virgin Islands sheep flock have <4% CP, 20% TDN, 11% ADF and 15% NDF (Godfrey and Dodson, 2003; Godfrey *et al*., 2003). The ewes grazed a set of pastures as a single flock and had access to the same quality and quantity of forage so it is probable that the additional concentrate feed was not sufficient to meet the nutritional demands of the ewes that received feed and they did not produce more milk than the control ewes.

Similar to milk production, litter weaning weight in the previous study (Godfrey and Dodson, 2003) was increased by feeding ewes in the dry season. The litter weaning weight being reported is higher than that reported by Godfrey and Dodson (2003). Part of this difference could be that the current study included Dorper x St., Croix White ewes and the previous study used only St., Croix White ewes and we have reported that Dorper x St., Croix White ewes have a higher litter weaning weight and ewe efficiency than St., Croix White ewes (Godfrey *et al*., 2010). It has also been reported that there was no difference in ewe efficiency or milk production among St., Croix White, Barbados Blackbelly and Gulf Cost Native ewes (Godfrey *et al*., 1997). Because ewe BW at weaning, litter size and litter weaning weight were similar it is not unexpected that ewe efficiency is not different. Feeding lactating ewes during the dry season resulted in increases in milk production, lamb weaning weight and preweaning ADG but this was evident during the wet seasons when forage was not limiting (Godfrey and Dodson, 2003). Without any significant increase in production traits (milk production, litter weaning weight or ewe efficiency) in the present study when forage was managed so as not to be limiting there was no impact on milk yield and lamb weaning weight.

CONCLUSION

The results show that feeding lactating ewes twice a day resulted in higher total feed intake and lower weight loss during lactation compared to control ewes. There was no effect of feeding regimen on PPI, milk production, litter weaning weight, ewe efficiency or subsequent lambing rate. Feeding lambs twice a day resulted in higher total weight gain and ADG than feeding lambs once a day, regardless of time of day of single feeding. The increased labor involved in feeding a split ration to lambs needs to be evaluated in relation to the increases in production traits to determine if use of this management practice is feasible.

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