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Original article

Seasonal variation in ovarian and oestrous activity of tropical Menz sheep as affected by plane of nutrition

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Summary — Forty-eight mature Ethiopian Menz ewes were used to investigate the effect of nutrition on oestrous and ovarian activity in tropical sheep. A control group was fed on hay alone and a high nutrition group received an additional 400 g per ewe per d of a concentrate feed providing 263 g crude protein/kg dry matter and 10.5 MJ metabolisable energy/kg dry matter. Half the ewes in each group interacted with harnessed vasectomized rams to detect oestrus, which was also verified by weekly plasma progesterone assays. Ram presence did not depress feed intake or liveweight gain ($P > 0.05$). The mean percentage of ewes showing oestrus at least once a month was very high (95%) and there was a marked reduction in sexual activity from June to September, the wet season. Only 79% of ewes cycled in August and the number of heats per ewe per month dropped to 1.3 during this wet season in contrast to 1.9 the rest of year. Ewes came into oestrus 21 times (range 18–23) a year with no significant effect of level of nutrition. Mean cycle duration was 17.9 ± 8.7 d; 22% of cycles were short (≤ 13 d), 56% normal (14–19 d), 11% long (20–26 d), 8% silent or missed (27–40 d) and 3% represented anoestrus (≥ 40 d) with no major difference due to nutrition level. Individual animal progesterone profiles revealed that ewes failing to show oestrus had experienced increased silent ovulations. Forty percent of undetected heats were from the same animals. We concluded that, although Menz ewes are year-round breeders, they experience an apparent reduction in sexual activity from June to September, which appears to be independent of the level of nutrition, but might influence their breeding activity and flock production.

tropical sheep / season / oestrus activity / ovulation / nutrition

Résumé — Variations saisonnières du comportement d'œstrus et de l'ovulation chez la brebis Menz ; effets de l'alimentation. *Les effets du niveau nutritionnel sur le comportement d'œstrus et l'ovulation ont été étudiés chez 48 brebis Menz éthiopiennes. Un lot contrôle était nourri uniquement au foin alors que le lot supplémenté recevait en plus 400 g/j de concentré (263 g protéines/kg MS et 10,5 MJ d'énergie métabolisable/kg MS). La moitié des brebis de chaque lot était au contact d'un bélier vasectomisé afin de détecter l'œstrus. Les résultats de cette détection étaient confirmés par des dosages hebdomadaires de progestérone. La présence du bélier n'a pas affecté la consommation alimentaire ou le gain quotidien. Le pourcentage de brebis présentant au moins un œstrus par mois est élevé (95%), avec cependant une nette réduction pendant la saison humide (juin à septembre). Durant le mois d'août, 79% des brebis étaient cycliques et le nombre d'œstrus par mois pendant la saison humide n'était plus que de 1,3 par brebis (alors qu'il est de 1,9 hors période hu-*

mide). Vingt et un comportements d'œstrus (18 à 23) ont été détectés en moyenne pour chaque brebis. Le niveau alimentaire n'a pas affecté ce paramètre. La durée moyenne du cycle était de 17,9 ± 8,7 j ; les cycles «courts» (≤ 13 j), normaux (14–19 j), longs (20–26 j) représentaient 22,56 et 11% des cas respectivement. Dans 8% des cas, l'œstrus n'était pas détecté (cycle de 27 à 40 j) et dans 3% des cas, une période d'anœstrus (intervalle entre œstrus ≥ 40 j) était présente. Le niveau alimentaire n'affectait pas cette distribution. Le suivi des profils plasmatiques de progestérone a montré que pendant les périodes où l'œstrus était absent, des ovulations silencieuses se produisaient. Les résultats de cette étude montrent que les brebis Menz sont peu saisonnées, avec seulement une légère dépression de l'activité sexuelle au cours de la période humide. Aucune interaction entre alimentation et variations saisonnières de l'activité sexuelle n'a été mise en évidence.

brebis / saison / œstrus / ovulation / nutrition

INTRODUCTION

Sheep productivity can be assessed by the number of offspring per breeding animal per unit time. Sheep from temperate regions exhibit marked variation in reproductive activity during the year (Karsh *et al,* 1984). This tendency is, however, markedly reduced towards the equator where ewes can cycle throughout the year (Mittal and Ghosh, 1980; Hombolu *et al,* 1985). However, while this indicates the natural potential to lamb every 8 months, often, for example, in the Ethiopian highlands where 70% of the country's 24 million sheep are found (Teferawork, 1989), only 65% of ewes lamb every 8 months, suggesting that certain periods of the year are more favourable to oestrous cyclicity. Increasing the proportion of ewes lambing 3 times every 2 yr to 80% is considered a reasonable goal to improve farmer income. This study was designed to investigate the seasonal pattern in oestrous behaviour of Menz ewes as influenced by the level of nutrition and climatic factors by recording the service dates of ewes interacting with vasectomised rams, and monitoring corpus luteum presence through weekly plasma progesterone determinations. In the process, animal liveweight changes were also recorded. Locally available feeds were used to formulate a supplementary diet for animals that were otherwise maintained only on native pasture hay. This information is regarded as important for flock management in relation to critical periods of the reproductive and grazing cycle or under more intensive breeding management.

MATERIALS AND METHODS

Location, animals, design and management

This study was undertaken at the ILCA Debre Berhan station located at an elevation of 2 780 m, latitude 9°36'N and longitude 39°38'E. Annual rainfall from 1977 to 1992 averaged 920 mm; 75% of which occurs during the long rain season from June to September, the rest as short showers from February to May with a dry period from October to January. Mean minimum and maximum temperatures were 5.4 and 19.0°C, respectively. Relative humidity is 67.0% and the day-length variation between the summer and winter solstices is just 1 h (fig 1).

Forty-eight pluriparous ewes of the Menz breed (Galal, 1983) were used, aged 3 to 5 yr, liveweight mean 22.9 ± 4.5 kg and condition score of 2.5 ± 0.6 (0 = emaciated and 5 = obese; Hossamo *et al,* 1986). Animals were divided by weight into 4 groups of 12 ewes each to assess the effect of nutrition (low or high) and ram presence (exposed or isolated) on liveweight gain and oestrous cyclicity. Ewes were confined under a natural photoperiod in shel-

tered semi-open pens for a year from April 1991. All the ewes had weaned a lamb and were cycling over the 5 months preceding the start of the trial.

Ewes on low nutrition were fed only hay *ad libitum*. Animals on high nutrition received an additional 400 g per head per d of a suplementary concentrate feed providing 263 g crude protein/kg DM (DM: dry matter) and 10.5 MJ ME/kg DM (ME: metabolisable energy) (table I). The dietary supplement was formulated from locally available by-product feeds. Hay intake was determined monthly by feeding 25 kg hay per group and weighing the lelf-over hay and wastage 24 h later. Supplementary feed was always completely consumed. The hay was harvested from the station during the months of October and November 1990. The hay was stacked under a properly rain-proofed shed, resulting in minimal variation in the composition of the hay, and providing a good source of forage throughout the study period. A hay sample was taken every 2 months, and a sample of the concentrate every time a new mix was made. These samples were analysed using standard proximate methods for DM and crude protein (AOAC, 1990). Neutral detergent fibre (NDF), acidic detergent fibre (ADF) and lignin were determined as described by Van Soest and Robertson (1985). The sam-

Table I. Chemical composition of the hay and concentrate supplement fed to Menz ewes for the year.

	Hay	*Concentrates* [1]
Dry matter, g/kg DM	925.0	914.0
Crude Protein, %	6.9	26.3
ME, MJ/kg DM	8.0	10.5
NDF, g/kg DM	681.0	444.0
ADF, g/kg DM	405.2	201.0
Lignin, g/kg DM	60.2	86.0
In vitro digestibility, %	55.8	65.0
Calcium, g/kg DM	6.3	5.4
Phosphorus, g/kg DM	1.0	8.6
Ash, g/kg DM	89.2	134.0

[1] Comprising 33.0% wheat bran, 65.5% noug cake *(Guizoitica abyssinica)*, 1.0% limestone and 0.5% salt.

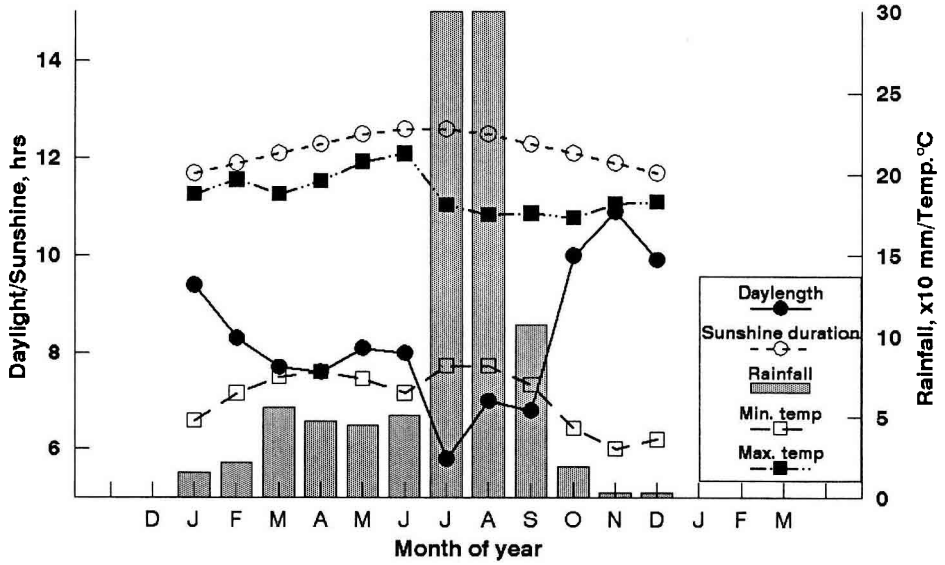

Fig 1. Annual changes in length of daylight, sunshine duration, rainfall and temperature at the Debre Berhan station (Source: Meteorological Dept and ILCA Data).

ples for calcium determination were digested and read by atomic absorption spectrophotometry (Perkin–Elmer, CT, USA), while phosphorus was assayed by the continuous flow analysis method developed by Chemlab Instruments. Water was provided *ad libitum* and ewes had free access to mineral blocks comprising 50, 40, 5 and 5% salt, bone meal, limestone and molasses, respectively, and 2 000, 1 500, 1 000 and 20 ppm zinc, copper, manganese and cobalt sulfates, respectively. Animals were drenched with Panacur (Fenbendazole, Hoechst, Germany) against the nematodes regarded as the major problem for housed animals.

Measurements, sample collection and oestrous interpretation

Animals were weighed and condition-scored by the same person every 15 d. Oestrous cycle duration was determined as the number of d between 2 consecutive heats. Sexual activity for exposed ewes was based on mating marks from vasectomised rams fitted with a harness and a crayon maintained with the exposed groups all the time. The rams were changed fortnightly. Ovulation was ascertained by blood samples taken to determine plasma progesterone (Yenikoye, 1984). Samples were taken every Friday by jugular venipuncture (10 ml) between 10.00 and 11.30 am. Plasma was separated by centrifugation and stored at –20°C until it was assayed for progesterone by the enzyme-linked immunosorbent assay (ELISA) method using Ovucheck kits (Cambridge Life Sciences) as described by Mukasa-Mugerwa *et al* (1989).

Sexual activity was assessed as: (i) percentage of ewes showing oestrus each month; and (ii) maximum number of oestruses per month. The oestrous cycle length was classified as short (≤13 d), normal (14–19 d) and long (20–26 d). Ewes with a cycle of 27–40 d were assumed to have had a silent oestrus or a heat missed by rams while a cycle of over 40 d was judged to represent anoestrus (Aboul-Naga *et al,* 1991).

Statistical analyses

Monthly liveweight and condition scores were analysed by the general linear models procedure of SAS (1988) using the repeated-measures analysis of variance with 2 factors: ram and nutrition and 1 interaction (ram x nutrition). The number of oestruses per ewe per year was analysed by standard analysis of variance procedures. Group means are reported as least-squares means ± SEM.

RESULTS

Oestrus cyclicity

Service dates for the ewes exposed to rams showed that Menz sheep exhibit high sexual activity all year, 95% of animals being able to manifest oestrus at least once a month. This pattern was also consistent with results from the individual progesterone profiles of both exposed and unexposed ewes. However, there was a period of definite reduced sexual activity from June to September, the wet season, when the percentage of cycling animals declined to a minimum of 79% in August. The total number of heats also dropped to 29 in June (fig 2). This decline was not significantly influenced by feeding level. Nevertheless, although the number of heats per ewe per month declined to 1.3 during the wet season, in contrast to 1.9 the rest of year, there was no period when the majority of animals were completely in anoestrus.

Ewes came into oestrus 21 times a year (range 18–23), or 1.8 times a month with no difference that could be ascribed to the level of nutrition. The mean oestrous cycle duration was 17.9 ± 8.7 d (range 5–68), being similar at the low and high levels of feeding (17.6 ± 0.5 *vs* 18.3 ± 0.6 d, respectively, $P = 0.0548$). Altogether 56.2% of cycles were of normal length (22.2% short, 11.3% long), 7.7% were associated with silent ovulation or missed teaser ram, and only 2.6% represented a period of anoestrus. Ewes on lower nutrition exhibited

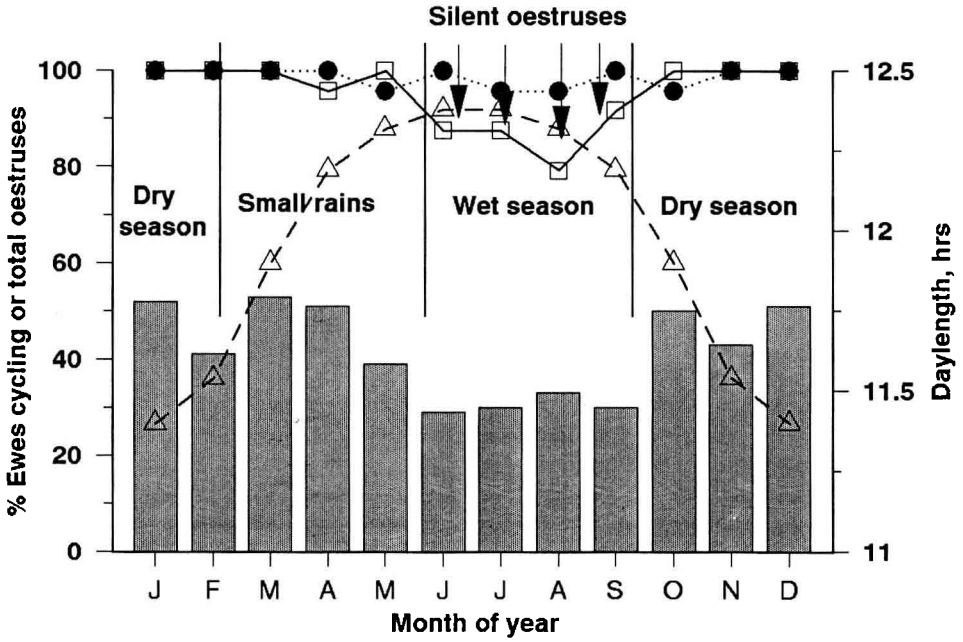

Fig 2. Seasonal variation between Menz ewes ovulating or showing oestrus (ewes ovulating: ●; ewes cycling: □; daylength: Δ; total oestruses/month: ■).

more short cycles (24.3 *vs* 20.1%) but fewer long cycles (8.5 *vs* 14.0%, table II) but these differences were not significant (χ^2 = 2.741, P = 0.254). Twenty-two percent of short cycles ranged from 5 to 8 d.

The animals that did not cycle every month in the wet season were as heavy in the preceding month of May as those that cycled regularly (28.1 ± 0.9 *vs* 27.9 ± 0.8 kg) and the 2 groups maintained similar mean liveweights throughout the wet season (28.7 ± 1.2 *vs* 28.3 ± 1.0 kg). Cycles of normal duration were 15% less during the wet season relative to the rest of year (table II).

After examining the individual animal progesterone profiles, it was observed that the failure of some ewes to show oestrus in the wet period resulted from an increased frequency of ovulations that were not accompanied by oestrus (silent heats) (fig 3). The seasonal variation in the frequency of silent oestrus is superimposed in figure 2. Forty percent of undetected oestruses were found to be from the same ewes.

Feed intake

Hay intake averaged 1.35 ± 0.16 kg per head per d with limited variation (CV = 12%) through the year. Mean daily DM intake of hay and concentrate supplement is shown in table III. Total DM intake per metabolic body weight did not differ significantly between the groups (P > 0.05). Unsupplemented ewes consumed significant-

Table II. Distribution of oestrous cycle length relative to the duration of day-length and nutrition level in Menz ewes ($n = 24$).

Period	*Obs*	*Type and duration of oestrous cycles (%)*				
		Short ≤ *13*	*Normal* 14–19	*Long* 20–26	*Missed* 27–40	*Anoestrus* ≥ *40*
June–Sept [a], wet	122	18.0	45.2	9.8	18.0	9.0
Oct–January, dry	246	23.6	65.9	10.5	–	–
Feb–May, light rain	118	18.6	51.8	16.1	12.7	0.8
Oct–May (combined) [b]	364	21.9	61.3	12.3	4.1	0.4
Nutrition level						
Low	235	24.3	57.4	8.5	6.8	3.0
High	229	20.1	55.0	14.0	8.7	2.2
Overall	486	22.2	56.2	11.3	7.7	2.6

[a] Increased and [b] decreased day-length season.

ly more hay ($P < 0.05$) but the extra concentrate feed resulted in 14% higher feed energy and 98% crude protein intakes for supplemented animals ($P < 0.001$–0.05). Within nutrition treatment group, there was no significant effect ($P > 0.05$) of ram presence on hay, DM or crude protein intakes (table III).

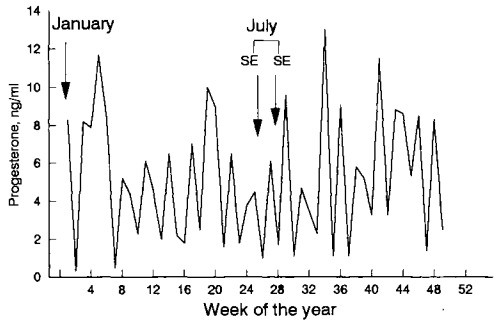

Fig 3. Progesterone profile of a Menz ewe R831 that was exposed to a vasectomised ram but was anoestrus in July due to silent oestrus (SE).

Liveweight and condition score gain

Although the mean monthly weight of ewes maintained with rams was lighter than that for their isolated counterparts the differences were not significant. There was, however, a trend towards higher average daily gains and liveweights for supplemented ewes starting 1 month into the study (84.7 ± 9.7 *vs* 76.3 ± 9.7 g per d), the difference becoming significant from 120 d ($P < 0.05$–0.001, table IV). Ewes maintained on hay alone attained the maximum mean liveweight at 90 d which they maintained until 150 d before a gradual decline to near the initial weight. In contrast, supplemented ewes exhibited steady liveweight gains for 9 months, to a maximum mean of 34.5 ± 0.8 kg before they too experienced weight loss back to 32.6 kg. Nonetheless, despite the terminal declines in mean liveweights, there was an overall gain ranging

Table III. Mean daily intake of dry matter (DM), energy and protein intake by treatment group in Menz ewes.

Group	*Low nutrition*		*High nutrition*		*Overall*
	no ram	*+ ram*	*no ram*	*+ ram*	*mean (SE* [a])
Hay intake, kg DM per d	1.38	1.31	1.15	1.12	1.24 (0.06)*
Supplementary feed intake, kg DM per d	–	–	0.36	0.36	
Total DM intake, per MW g per d	112.6	112.1	109.5	110.9	111.3 (5.46) NS
Total ME intake, MJ ME per d	11.0	10.5	12.4	12.2	11.5 (0.47)**
Crude protein intake, g per d	95.6	90.9	174.8	172.7	133.5 (4.09)***

[a] SE: pooled standard error of means; LN: low nutrition; HN: high nutrition; ME: metabolisable energy; MW: metabolic weight ($wt^{0.75}$); NS: not significant; * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

from 1 to 9 kg for isolated animals on low and high nutrition. There was wide variability in individual animal weights within treatments, sometimes up to 1.5-fold. The maximum individual animal weight attained was 44 kg. Basically similar patterns were recorded for changes in animal body condition (table IV).

DISCUSSION

The results of this study demonstrated the natural potential of Menz ewes for continuous ovarian cyclicity and, in the process, the ability of mature animals to respond to improved feeding management even when fed only hay was also noted. Observations based on blood progesterone profiles, revealed that unexposed ewes were capable of cycling as frequently throughout the year, suggesting, that there was limited 'ram effect' on the oestrous activity of exposed animals.

The seasonal variation in the breeding activity of tropical sheep is often attributed to environmental signals like temperature, humidity, management and nutrition (Molokwu and Umunna, 1980; Hombolu *et al,* 1985; Thimonier *et al,* 1984). Pasture availability and quality are linked to rainfall patterns, the wet season tending to stimulate maximum ovarian activity for grazing animals (Hombolu *et al,* 1985). However, although ewes in this study cycled year-round in accord with previous reports (Mittal and Ghosh, 1980), their oestrous activity declined in the rainy season. These ewes had, however, been confined and ovarian activity could not be directly linked to grazing conditions. Furthermore, ambient temperatures were not extreme

Table IV. Quarterly changes in liveweight and body condition score of Menz ewes as affected by nutrition level and ram presence (Least Squares mean ± SEM).

	Low nutrition		*High nutrition*	
	no ram	*+ ram*	*no ram*	*+ ram*
Initial				
Weight, kg	28.5 ± 0.8	26.0 ± 0.9	27.5 ± 0.8	26.8 ± 0.9
Condition score	2.1 ± 0.2	2.3 ± 0.2	2.8 ± 0.2	2.4 ± 0.2
3 months				
Weight, kg	29.0 ± 0.9	27.4 ± 0.9	29.9 ± 0.8	28.6 ± 0.9
Condition score	2.5 ± 0.2	2.6 ± 0.2	3.7 ± 0.2	3.0 ± 0.2
6 months				
Weight, kg	29.6 ± 1.0	26.1 ± 1.1	32.9 ± 1.0	30.7 ± 1.1
Condition score	2.7 ± 0.1	2.6 ± 0.1	4.2 ± 0.1	3.7 ± 0.1
9 months				
Weight, kg	27.9 ± 1.1	27.3 ± 1.1	35.1 ± 1.1	33.9 ± 1.1
Condition score	2.3 ± 0.1	2.5 ± 0.1	4.3 ± 0.1	4.1 ± 0.1
12 months				
Weight, kg	26.1 ± 1.4	26.2 ± 1.4	33.8 ± 1.4	31.6 ± 1.4
Condition score	2.6 ± 0.2	2.6 ± 0.2	4.5 ± 0.2	4.1 ± 0.2

enough to modify animal reproductive processes. In addition, the liveweight changes recorded suggested that energy levels even for animals fed only hay would not limit sexual activity.

A significant observation was that ewes that were externally non-active in the wet season had actually ovulated, as evidenced by plasma progesterone profiles (Ammar-Khodja and Brudieux, 1982) but oestrus had been silent. Silent ovulations have been reported in Menz (Mukasa-Mugerwa and Zere, 1991) and Peulh ewes elsewhere in the tropics (Yenikoye, 1984) but this is the first time they have been associated with seasonality. The observation that ewes failing to cycle every month were as heavy as those that cycled, was interpreted as an indication that the nutrition and liveweight of the ewes as they approach the wet season and throughout this period, are not major potentiating factors for the depressed sexual behaviour observed. This was consistent also with the observation that treatment groups displayed similar oestrous activity, suggesting, again, that nutrition does not limit the oestrous activity of ewes. In all cases, the total ME intake was sufficient for maintenance, estimated at 4.5 ME, MJ per d, and some level of production. Although the protein intake by the unsupplemented ewes was below the 10 g per ME intake regarded as the minimum amount of degradable protein required to meet the protein needs for tissue maintenance and wool growth (Robinson, 1986), it was suspected that the mineral block made up for the deficiency. Consequently, the energy and protein supplies in all treatment groups would have sustained ovarian cyclicity.

The June to September season coincided with increasing day-length (fig 1). It was therefore tempting to conclude that the photoperiod, the principal factor determining the length and timing of the breeding season in temperate ewes (Karsh *et al,* 1984), might also be operative in tropical sheep *albeit* to a lesser extent. This hypothesis is supported by the trend in available data but needs further investigation. For example, the mean frequency of 95% ewes exhibiting at least 1 oestrus a month in this study as higher than 90% observed for Creole and Black Belly ewes in Martinique, West Indies (Mahieu *et al,* 1989), 80% in Marwani sheep in Rajasthan, India (Mittal and Ghosh, 1980) and 50% for D'Man ewes in North Africa (Lahlou-Kassi and Marie, 1985). It is thus conceivable that while sheep at higher latitudes respond to changes in day length with true anoestrus, at lower latitudes ewes manifest increased silent ovulations. However, elsewhere in the tropics where temperatures and other environmental factors can be more harsh than in Debre Berhan, these might be more influential on sheep breeding seasonality.

The natural potential of Menz sheep to cycle all the year round offers an opportunity to increase regional meat production through more intensive lamb production systems, possibly combined with organised early lamb-weaning schemes. The reproductive patterns of these animals can be manipulated to optimise feed availability or production patterns to meet the demand for finishing or fattening market animals particularly during festival periods when demands are high. There is a need to identify the physiological mechanisms underlying silent ovulation in tropical female sheep so that their aseasonality can be maximized in the wet season. In this regard it was noteworthy that 40% of ewes with undetected oestrus were the same, suggesting detectable animal variability in the seasonality of silent oestrous. Although this must be verified with a larger number of animals, it would offer the possibility of selecting against the trait. Initially, however, studies on the fecundity of free-mating Menz ewes during the rainy season, the present period of depressed sexual activity might give an initial indication of the effect of seasonality on fertility. Subsequently, the effectiveness of increasing lambing percentage in order to register significant increases in farmer income would also require further investigation.

Changes in ewe sexual activity can nevertheless not be completely isolated from ram breeding activity. Moreover, standing to be mounted is the external criterion often adopted to judge the duration of the ewe sexual season even though this depends also on ram libido. While this needs further verification, it is therefore possible that some oestruses were only missed by rams whose testicular function and libido might also have seasonally waned as previously reported for temperate and more tropical breeds (Sinha *et al,* 1979; Pelletier and Almeida, 1987; Boland *et al,* 1985; Trejo *et al,* 1990). However, missed heats were rare because of the good ram/ewe ratio and that ewes in oestrus were always heavily marked.

Finally, low reproductive rates and the need for replacements often limit strong selection among ewes but, where this can be organised, the need to maximise culled animals becomes important. Our results showed that when mature ewes grazing native pastures are confined and fed on hay alone, they made positive early weight gains. This suggests that smallholder fattening schemes could be based on culling unproductive mature animals. As a general guide for the feeding management of mature ewes, the maximum individual weight of 44 kg was regarded to be near the upper limit of the genetic potential for ewes of the Menz breed. The decision to feed

mature animals on scarce hay, let alone concentrates, would need to be gauged against : i) the premium to be realised for improved liveweights and carcass quality; ii) the feasibility of using on-farm feed inputs; and iii) the extent to which the cost of non-feed inputs can be minimised. In particular, cutting fodder in the wet season and conserving it for dry-season fattening is likely to be a major inhibitor to intensive sheep management as it would occur at a time when farm labour is also required for other farm activities.

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