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Effects of mimosine on fiber shedding, follicle activity, and fiber regrowth in Spanish goats¹

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ABSTRACT: Ten 2-yr-old Spanish wethers (58.2 ± 7.21 kg BW) were used to determine effects of 2-d intravenous infusion of mimosine (beginning on January 8) on fiber shedding, follicle activity, and fiber regrowth. Primary and secondary follicle activity on d 0 were $43 \pm 6.2\%$ and $96 \pm 1.7\%$, respectively. Five wethers were infused with mimosine at 120 mg/(kg BW·d) and the other five received saline. At 7 to 10 d after the start of infusion, all five goats infused with mimosine exhibited shedding, whereas shedding by controls was not observed. Cashmere fiber shedding score (5-point scale: 1 = no shedding, 5 = excessive shedding) on d 4 was greater for mimosine goats than for controls (1.2 vs 2.0; $P < .001$), and shedding score for wethers receiving mimosine was greater ($P < .05$) on d 12, 16, and 20 than on d 0 and 4 (4.1 to 4.6 vs 1.4 and 2.0). Guard hair shedding score for goats receiving mimosine was greatest ($P < .01$) among the days after infusion for d

12 and greater ($P < .01$) on d 16 than on d 0 and 4. Nonetheless, cashmere fiber yield from combed fleece of mimosine goats (average of 73%) was much greater than for a clipping of the uncombed side (average of 28%) when the cashmere fiber shedding score exceeded 4.0. Secondary follicle activity on d 12 was lower ($P < .01$) for mimosine than for control wethers (6.8 vs 67.7%), and secondary follicle activity for mimosine-infused goats on d 12 was lower ($P < .01$) than on d 0 (98.9%), 4 (98.3%), and 20 (99.5%). Mimosine infusion resulted in no detectable fiber regrowth in wk 4 to 7 after the start of infusion, but regrowth rate in the following two 4-wk periods was similar for mimosine and control wethers. In conclusion, 2-d intravenous infusion of mimosine at 120 mg/(kg BW·d) in the winter induced cashmere shedding but had less effect on guard hairs, suggesting future potential use of chemicals such as mimosine to remove cashmere fiber.

Key Words: Cashmere, Defleecing, Follicle Activity, Mimosine, Spanish Goats

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Introduction

Mimosine is present in seeds and leaves of *Leucaena leucocephala*, a tropical leguminous shrub or tree. Mimosine has been proven effective in defleecing sheep and Angora goats. In sheep, intravenous infusion of mimosine at ≤ 80 mg/(kg BW·d) for 1.5 to 2 d has consistently caused follicle retrogression and an abrupt, temporary cessation of wool growth without toxic side effects, allowing subsequent manual fleece removal (Reis et al., 1975; Reis and Panaretto, 1979). Single large oral doses (e.g., 400 to 600 mg/kg BW) of mimosine have been effective in producing a complete break in fleece as well (Hegarty et al., 1964). Fleece shedding in Angora goats receiving dietary mimosine

at 700 mg/kg BW^{0.75} occurred, although medullated fibers were retained presumably because of inactive follicles at that time (Jacquemet et al., 1990).

Mimosine is a pyridoxal antagonist, which inhibits DNA replication and protein synthesis; thus, it may elicit defleecing by arresting cell division in the follicle bulb (Reis, 1979). A study on annual patterns of follicle activity in Australian cashmere goats indicated that primary follicles were largely inactive during the winter (short day length); secondary follicles became inactive about 1 mo later and remained so for only a short period of time (Coop, 1982). This difference between follicle types may provide an opportunity to chemically defleece or remove cashmere fiber with minimal guard hair contamination. In addition, typically, cashmere goats are shorn when the mean temperature is around 10°C in the early spring. Because shorn goats are susceptible to cold stress for up to 3 mo (Mitchell et al., 1989; Litherland et al., 1992), retention of guard hair would be very useful in cold weather. Therefore, objectives of this experiment were to evaluate the effects of mimosine infusion on fiber shedding, follicle activity, and fiber regrowth in Spanish goats.

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Materials and Methods

Animals and Management

Forty-six 2-year-old Spanish cashmere wethers were selected in December, 1997, from the herd of the E (Kika) de la Garza Institute for Goat Research, Langston, OK, USA (97°20' E, 35°50' N). The experimental protocol was approved by the Langston University Institutional Animal Care and Use Committee. Ten wethers, with an average BW of 58.2 ± 7.21 kg, were identified for the experiment based on primary and secondary follicle activities assessed from biopsy skin samples (Nixon, 1993). The wethers had free access to water and were fed a mixed diet (14% CP) daily at 0900 for ad libitum consumption. Wethers were maintained individually in metabolism crates during the infusion portion of the experiment, having been previously accustomed to the crates for 1 wk before the start of the infusion period. After 2 d following the completion of infusions, wethers were moved to a pasture with dormant grass and continued to receive ad libitum access to the same mixed diet.

Treatments

Wethers were fitted with two indwelling jugular vein catheters (i.d. .86 mm and o.d. 1.27 mm; Becton Dickinson and Company, Sparks, MD) under local anaesthesia 1 d before infusion commenced using the technique described by Al-Dehneh et al. (1994). Wethers were stratified by primary follicle activity and BW, and then randomly divided into two groups. One group was infused with mimosine-saline (.9%) solution at 120 mg/(kg BW·d), and the other group (control) received saline. The mimosine dosage level and length of infusion used were based on previous studies with sheep and goats (Reis et al., 1975; Litherland et al., 1998). A dosage slightly greater than used by Litherland et al. (1998) with Spanish goats was chosen because, in their experiment, infusion with 100 mg/(kg BW·d) of mimosine elicited defleecing in only three of six goats. Mimosine infusate was prepared for each animal by dissolving mimosine (Sigma Chemical Co., St Louis, MO) in 50 to 100 mL of saturated NaOH solution. Once mimosine was in solution, the infusate volume was increased by addition of sterile saline, and the pH was adjusted to 8.0 with HCl before vacuum filtration into sterile bottles. Infusate was transferred to sterile plastic bags and kept refrigerated until use. Prior to infusion, catheters were flushed with 100 IU/mL of heparin saline. Intravenous infusion was conducted for 48 h from 1100 on January 8 until 1100 on January 10. Fixed-speed mini-peristaltic pumps (Harvard Apparatus, South Natick, MS) were used to deliver infusate to the venous jugular catheter at 10 mL/h.

Samples and Analyses

Follicle Activity. Skin samples were taken by biopsy punch (8-mm diameter) from the right side before infu-

sion (d 0) and 4, 12, and 20 d later. Skin samples in cassettes (Fisher Scientific, Pittsburgh, PA, USA) were fixed in 10% buffered formalin (Fisher Scientific, Fairlawn, NJ, USA), were then processed through graded concentrations of ethanol, and were embedded, epidermal surface uppermost, in paraffin wax. The 8- μ m sections of embedded skin were serially cut in the transverse plane on a rotary microtome (Shandon Southern Product Ltd., Astmoor, Runcorn, Cheshire, England), stained with adapted saopic stain, and examined microscopically; primary and secondary follicle activities were assessed according to the staining characteristics of the inner-root sheath and flattening of outer-root sheath cells (Nixon, 1993).

Fiber. Straightened fiber (cashmere fiber and guard hair) length was measured on the neck, front shoulder, mid-side, and rump at each skin sampling date, and values were averaged. A 100-cm² patch (10 × 10 cm) on the right mid-side of each goat was clipped and marked 20 d after treatment commenced, with procedures similar to those of Sahlu and Fernandez (1992). Clean dry fiber regrowth rate was determined by clipping at skin level using Oster animal clippers (size 40; Oster, McMinnville, TN) at 4-wk intervals for 12 wk. During clipping, goats were restrained with a portable head catch with a soft leather collar, and also manually. The goats were calm during clipping, either initially so or quickly becoming accustomed to frequent human presence and handling and the sound of clippers. Static electricity did not impair the ability to quantitatively collect clipped fibers, and great care was exercised during sampling to harvest any fibers retained on clipper blades.

The amount of fiber lost from the body at each sampling time was assessed by both combing and visual scoring. A hand comb was drawn horizontally and then vertically through the fleece in a single pass over the whole left side of the goat; captured fiber was considered shed. Shedding was also assessed on the right side of the goat by hand-plucking fleece prior to combing of the left side. The amount of fiber plucked was scored from 1 (no shedding) to 5 (excessive shedding). When the cashmere shedding score rose above 4, a mid-side strip (5 × 50 cm) on the right side was clipped to skin level. Combed fleece and the mid-side strip were assessed for cashmere yield (Lupton et al., 1995) and fiber diameter (Baxter et al., 1992) using an optical fiber distribution analyser (OFDA 100; Zellweger Uster, Charlotte, NC).

Statistical Analyses

Data were analyzed as a completely randomized design using the GLM procedure of SAS (1990). Data were analyzed with a split-plot design, with treatment as the main plot and sampling date or time as the subplot; treatment effects were tested using animal within treatment as the error term. The treatment × sampling date or time interaction was nonsignificant

Table 1. Effects of mimosine infusion (120 mg/[kg BW·d]; 48 h) of Spanish goat wethers on guard hair and cashmere fiber length and shedding, fleece weight, follicle activity, and fiber regrowth rate¹

Item	Day after infusion	Treatment		SE	P-value
		Mimosine	Control		
Guard hair length, cm	Mean	6.54	6.69	.404	.80
Cashmere fiber length, cm	Mean	6.82	7.56	.947	.59
Guard hair shedding score ²	0	1.10 ^a	1.30	.158	.40
	4	1.30 ^a	1.10	.158	.40
	12	3.00 ^c	1.30	.346	.01
	16	2.30 ^b	1.20	.255	.02
	20	1.70 ^{ab}	1.10	.158	.03
Day SE		.276	.167		
Cashmere fiber shedding score ²	0	1.40 ^a	1.20	.112	.24
	4	2.00 ^a	1.20	.087	.001
	12	4.20 ^b	1.20	.357	.001
	16	4.60 ^b	1.20	.194	.001
	20	4.10 ^b	1.20	.500	.003
Day SE		.392	.141		
Combed fleece weight, g	4	2.84 ^a	.89	.663	.07
	12	30.81 ^{bc}	1.32	10.787	.09
	16	42.74 ^c	.86	4.618	.001
	20	17.35 ^{ab}	.82	1.318	.001
Day SE		8.357	.280		
Primary follicle activity, %	Mean	38.8	39.0	7.78	.98
Secondary follicle activity, %	0	98.9 ^b	93.1 ^b	2.08	.09
	4	98.3 ^b	96.9 ^b	1.23	.43
	12	6.8 ^a	67.7 ^a	9.78	.003
	20	99.5 ^b	88.6 ^b	3.06	.04
Day SE		1.47	6.47		
Fiber regrowth rate, mg/(cm ² ·d)	21–49	0 ^a	.214 ^b	.0342	.002
	50–77	.206 ^b	.186 ^a	.0691	.84
	78–105	.402 ^c	.388 ^c	.0871	.91
Day SE		.0787	.0533		

¹Differences between mimosine and control treatments are reflected by the associated SE and *P*-value columns, and differences among days by Day SE rows and superscript letters.

²1 = no shedding; 5 = excessive shedding.

^{a,b,c,d}Within a column, means lacking a common superscript letter differ ($P < .05$).

($P > .05$) for primary follicle activity and fiber length and, thus, was removed from the model. For other variables with a significant interaction, data were analyzed by treatment and time. Differences among treatment means were determined by least significant difference when the treatment or time *F*-value was significant ($P < .05$). For goats infused with mimosine, cashmere yield and diameter were analyzed with a model consisting of sampling date or time.

Results

Fiber

Lengths of guard hair and cashmere fiber were similar between treatments and among days (Table 1). No appreciable quantity of fiber was harvested by combing control wethers. However, for goats infused with mimosine, shedding scores for both cashmere fiber (3.0) and guard hair (4.6) increased ($P < .01$) dramatically on d 12 and 16, respectively. Defleecing by mimosine infusion was first noticeable 7 to 10 d after infusion

started. Shedding started from neck and shoulder areas, where large amounts of cashmere fiber could be easily removed by plucking or combing. By d 12, a large amount of cashmere could be readily combed; however, cashmere fiber on the lower part of both front and hind legs remained. Although mimosine infusion did increase guard hair shedding score, albeit to a lesser degree than that of cashmere fiber, the proportion of cashmere in combed fleece was similar ($P > .05$) among days (78, 73, 70, and 72% on d 4, 12, 16, and 20, respectively; SE 6.1). Moreover, cashmere fiber percentages in combed fleece were considerably greater than a calculated cashmere fiber yield of 28.1% for the mid-side strip sample taken from the uncombed side on the day when the cashmere fiber shedding score exceeded 4.0. Cashmere diameter was similar among days (20.6, 20.1, 19.4, and 19.3 μm on d 4, 12, 16, and 20, respectively; SE .83).

Follicle Activity and Fiber Regrowth

During the 20-d sampling period following mimosine infusion, primary follicle activity remained low rela-

tive to secondary follicle activity (Table 1). Secondary follicle activity for control wethers was lowest among days on d 12. However, secondary follicle activity for mimosine wethers declined to 7% on d 12 compared with activity of 98 or 99% on other days. The defleecing effect of mimosine infusion resulted in no measurable fiber regrowth in wk 4 to 7, although rates in wk 8 to 11 and 12 to 15 were similar to those for control wethers.

Discussion

Mimosine Infusion and Defleecing

The intravenous infusion of mimosine over 48 h [120 mg/(kg BW·d)] was sufficient to obtain consistent and nearly complete defleecing of Spanish goats. This dosage resulted in complete cessation of fiber growth for a period of time, without observed toxic side effects. Toxic effects in sheep have been reported after infusion periods of 4 d (Reis et al., 1975).

Follicle Activity and Fiber Regrowth

Greater shedding of cashmere fiber than of guard hair is consistent with findings of Jacquemet et al. (1990), who demonstrated that most medullated fibers of Angora goats were retained after dietary inclusion of mimosine at 700 mg/kg BW^{0.75} or intravenous infusion of mimosine at 79, 102, or 135 mg/(kg BW·d) (Reis et al., 1999), presumably because primary follicles were inactive at times of mimosine administration. The present experiment was conducted in January, when primary follicle activity was lower but secondary follicle activity was greater than 90%. Again, guard hair retention as observed at this time of the year is important for cold protection.

Follicle activity changes due to mimosine infusion were essentially the same as those described for sheep by Hegarty et al. (1964) and Reis and Tunks (1978). Observed follicle retrogression between d 4 and 12 after the start of infusion agrees with Reis et al. (1975), who reported no sign of retrogression of follicle bulbs until 8 to 11 d after infusion began, and with Hegarty et al. (1964), who noted first signs of retrogression of follicle bulbs on d 3 after the onset of mimosine infusion. However, a portion of the decline in secondary follicle activity on d 12 for mimosine-treated goats may have been independent of mimosine infusion because it corresponded to a decline for control goats presumably related to seasonal hair follicle activity changes as seen in New Zealand cashmere goats (Nixon et al., 1991).

Converse to findings of this experiment, Reis and Tunks (1978) observed decreased wool fiber diameter in the early regrowth period after mimosine infusion. The impairment of fiber regrowth by mimosine infusion in wk 4 to 7 is also similar to observations after mimosine infusion of sheep (Reis et al., 1975; Reis and

Tunks, 1978) and Angora goats (Reis et al., 1999). However, no adverse effects of mimosine on subsequent cashmere fiber growth or diameter within the period of measurement of the present experiment do not suggest a long-term impact on cashmere production. Longer-term experiments are necessary to determine the existence or magnitude of impact of this short period of decreased cashmere fiber regrowth on annual production.

Implications

Mimosine is effective in removing the down fiber of Spanish goats, which is similar to responses observed in Angora goats and in sheep. Proper timing of treatment offers the potential to harvest the cashmere of Spanish goats with minimal guard hair contamination. Guard hair retention also offers the additional benefit of cold protection. However, further research is necessary to determine effects on annual cashmere fiber production and practical methods of mimosine administration.

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