Tropical and Subtropical Agroecosystems

SHORT NOTE [NOTA CORTA]

SELECTING ANGORA GOATS TO CONSUME MORE JUNIPER

[SELECCIÓN DE CABRAS ANGORA PARA UN MAYOR CONSUMO DE ENEBRO]

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SUMMARY

This research project was initiated in 2003 to develop a more effective tool for biological management of invading juniper species on rangelands through herbivory by Angora goats. After we had established that juniper consumption in free-ranging goats has a genetic component (heritability = 13%), male and female goats were bred selectively for above- (high) and below-average (low) juniper consumption that was estimated by fecal near-infrared reflectance spectroscopy. Divergent lines are being produced to facilitate the identification of physiological mechanisms that permit some goats to consume considerably more juniper than others as a regular component of their diet. Because diet is known to affect growth and fiber production, another objective of the project is to establish the effects of the selection protocol on body weights, fleece weights, and fiber characteristics. Mature females (age > 1.5 yr) and kids were maintained on rangeland and shorn twice a year. Extreme high- and low-consuming yearling males (10 of each per year) were evaluated annually in a central performance test. The selection protocol resulted in average EBV for percentage juniper consumption of 3.9 and -0.4 ($P < 0.0001$) respectively for the 2006-born high- and low-consuming yearlings. A physiological difference in bioavailability of monoterpenes between high and low consumers was recently detected. Fiber data for 2006-born 12-mo-old kid goats indicated no significant differences ($P > 0.1$) in body weight, mohair production and properties between high and low consumers. However, the adult data for the extreme males indicated that high consuming males have lower body weights than low consumers (53.8 vs. 57.9 kg, $P = 0.01$). Differences in body weight and several mohair production and quality traits have also been detected in the mature females but at this early stage of the selection program, no substantial differences have been observed and certainly none that would have an economic impact for producers. Ultimately, we expect to demonstrate that the high-consuming line controls juniper more effectively than either the low-consuming line or unselected Angora goats. Subsequently, we plan to release high juniper-consuming genetics to commercial breeders for use in range management.

Key words: *Angora goat, juniper, mohair, NIRS, selection.*

INTRODUCTION

Juniper encroachment of southwestern U.S. rangelands is having a negative impact on livestock production, water availability and quality, and wildlife habitats. The cost of conventional control methods (mechanical and chemical) is prohibitively high. Goats are known to consume juniper despite its high terpenoid content. Research conducted at the Texas AgriLife Research Station (formerly the Texas Agricultural Experiment Station) at Sonora has shown that animals vary in their consumption of juniper, indicating they may also vary in their ability to detoxify the terpenoids (Campbell et al., 2007). Research was initiated in 2001 to investigate the use of selective breeding to increase the preference of Boer x Spanish goats for juniper. Near-infrared reflectance spectroscopy of fecal material (fecal NIRS) was used to predict the percentage of juniper in diets of penned and free-ranging goats (Whitworth, 2002). Taylor et al. (2003) reported that heritability of juniper consumption in this meat goat population was 31%, indicating substantial scope for improvement by genetic selection. In May 2003, a flock that included 272 mature Angora females was added to the project to determine the juniper consuming potential of this breed. The 4 major objectives of the project to date have been: 1) improve the accuracy and precision of fecal NIRS equations for predicting juniper consumption in free-ranging goats, 2) use selective breeding to produce divergent lines of high and low juniper-consuming goats, 3) identify physiological and nutritional mechanisms of secondary chemical metabolism in high juniper-consuming goats and evaluate their capacity to consume other noxious brush species, and 4) monitor mohair production and quality in the high and low juniper-consuming selection lines. By selecting goats that exhibit increased preference for juniper, we are selecting animals with an unspecified higher physiological capacity to avoid pathological effects of terpenoids that could be correlated with production traits. Metabolic fate of the terpenoids involves hepatic biotransformation and subsequent excretion in urine (Sheline, 1991). This short communication summarizes progress in the 4 objectives but will focus primarily on the effects of selection on mohair production.

MATERIALS AND METHODS

Mature Angora females (n = 272) were purchased from 5 breeders in the summer of 2003 and maintained on rangeland at the Read Ranch, Crockett County, Texas (300° 32’ 53” N, 101° 3’ 27” W). In October 2003 and 2004, the nannies were mated to performance-tested males (one exception) purchased from 7 different breeders with the primary objective of increasing genetic diversity in the kids (Table 1).

Table 1. Number of male and female Angora goats bred by year.

Year	Number of females exposed	Number of sires	Method of exposure
2003	272	7	Single sire
2004	388	6	Group mated (high, low)
2005	150	7	Single sire
2006	161	8	Single sire
2007	147	8	Single sire

Parentage of the first two kid crops was established by DNA analysis of blood. In subsequent years, conventional methods (single-sire matings, pairing kids and nannies) were used to establish parentage of offspring. Percentage of juniper consumed by free-ranging nannies and kids was estimated using fecal NIRS (Walker et al., 2007) at 4 separate times throughout the first production year.

In subsequent years, these estimates were made from fecal samples collected in mid-winter. Estimated juniper consumption was used as a phenotypic trait in the calculation of Expected Breeding Values (EBV; Henderson, 1984) and an animal’s EBV was used to assign males and females to high and low juniper-consuming mating groups. The rationale was that by selecting for extreme consumers, we are more likely to discover (in future experiments) physiological reasons for the differences in juniper consumption. Since 2005, the 10 highest and 10 lowest juniper-consuming male yearlings were also evaluated in a central performance test (Waldron and Lupton, 2005). The males used to breed were selected primarily on their EBV for juniper consumption, but their overall performance in this test was also taken into account (one exception). In the fall of 2005, the high and low mature female population was reduced to 75 goats per selection line and the intermediate consumers were sold. Subsequently, as selected yearling nannies were included into the breeding flock, older and unsound goats were removed in order to maintain a total of about 150 breeding females. Because selection for increased (or decreased) juniper consumption could affect body weight, mohair production, and fiber properties, animals and fleeces were weighed after each biannual shearing (in February and August) and individual fleeces were analyzed (August 2005 to August 2007) for clean yield (ASTM, 2004a), fiber diameter (ASTM, 2001), staple length (ASTM, 2004b), opacity and medullation (IWTO, 1998 and ASTM, 2005), and fiber curvature (van Rensburg, 2000).

The GLM procedure of SAS (SAS Institute Inc., Cary, NC) was used to identify differences between high and low juniper-consuming goats for each of the measured or calculated traits. Separate analyses were performed for mature females (age = 18 months and older), performance-tested males, and current sires. Because sire was unknown for two thirds of the mature females, sire was not used in the model. Therefore, significance levels are not exact. The MIXED procedure of SAS was used to analyze data from the 2006-born kids at 12 months of age. The model used selection line and sex as fixed effects and sire and residual as random effects.

RESULTS AND DISCUSSION

Objective 1. NIRS calibration equations are normally developed and checked for accuracy in conjunction with reference samples and methods using standard laboratory procedures. In the case of fecal NIRS with goats, reference samples are not available and the accuracy of microhistological analysis of goat feces is not accurate or precise (Whitworth, 2002). We have concluded that fecal NIRS predictions of juniper consumption represent an interval scale of measurement (i.e., treatments can be ranked and the differences have meaning and are equal across the range of measurements). However, a true zero point is not known. Consequently, we have made no claims concerning the absolute quantities of juniper consumed by high and low groups. But we are confident that reported differences are correct. We have also shown that most non-treatment factors such as sex can bias predictions and comparisons (Walker et al., 2007).

To determine the appropriate season and sampling intervals to accurately estimate the true percentage of juniper in the goats' diet, data from a 2-year study on juniper intake were analyzed to test for the presence of long-term, short-term, and episodic periodicities. A model containing temperature, precipitation, and two autoregressive terms accounted for 71% of the variability of juniper in the diet. Inclusion of wind direction and barometric pressure into the model produced a small improvement in R^2 (to 0.75). A trend for high-consuming Angoras to consume greater percentages of juniper in their diet was observed for every month of this study.

Objective 2. Divergent selection within the Angora flock has been conducted for only 4 years. Nevertheless, divergence (as measured by EBV for % juniper consumption) has been observed between the high and low 2006-born kids (Table 3, 3.9 and -0.4, respectively) and a larger difference is present between the extreme high and low males being used to breed in 2007 (Table 5, 6.2 and -2.4, respectively).

Objective 3. A pharmacokinetic study identified conclusive evidence of a physiological difference in bioavailability of monoterpenes between extreme high and low juniper consuming goats. This result represented the first independent verification of the breeding program through identification of differences in physiological mechanism by which goats process juniper terpenoids (Taylor et al., 2007). In another study, protein supplementation of high consuming goats with soybean meal increased juniper in the diet by 5% (Campbell et al., 2007).

Objective 4. Tables 2 - 5 summarize EBV for juniper consumption, body weight, mohair production, and mohair quality traits for mature females (Table 2), 2006-born kids (12-month clip, Table 3), extreme male yearlings (Table 4), and extreme males used for breeding in 2007 (Table 5). Selection of mature females has resulted in the high consuming goats having smaller body weights (28.0 vs. 30.9 kg, P = 0.005), higher mohair production per unit of body weight (62.2 vs. 54.8 g/kg, P = 0.009), finer fiber (33.3 vs. 34.9 µm, P = 0.003), less flat fibers (19.7 vs. 28.0 per 10,000 fibers), and higher fiber curvature (15.5 vs. 14.6 deg/mm, P = 0.036). These differences were not present in the 2006-born kids (Table 3). Except for EBV means, no differences were detected between the high- and low-consuming kids measured at 12 months of age. The lack of differences in the kids suggests that the significant differences in the mature females should be interpreted with caution.

Table 2. Least squares means of expected breeding values, body weights, fleece weights, and fiber properties for high and low juniper-consuming mature (18 mo and older) Angora females at Fall 2007 shearing.

Item	High (83)	Low (95)	SE	*P*
Expected breeding value (% juniper consumption)	2.8^a	-0.9^b	0.2	< 0.0001
Body weight (kg)	28.0^b	30.9^a	0.7	0.0050
Grease fleece weight (kg, adjusted to 182.5 d)	2.0	1.9	0.05	0.3435
Clean yield (%)	83.1	83.1	0.5	0.9743
Clean fleece weight (kg, adjusted to 182.5 d)	1.6	1.6	0.04	0.3350
Clean mohair per unit BW (g/kg)	62.2^a	54.8^b	2.0	0.0089
Lock length (cm, adjusted to 182.5 d)	12.5	12.5	0.2	0.9528
Average fiber diameter (µm)	33.3^b	34.9^a	0.4	0.0025
Opacity (%)	51.8	51.5	0.2	0.3627
Total medullation (per 10,000 fibers)	69.9	80.3	3.9	0.0513
Objectionable fibers (per 10,000 fibers)	13.6	15.4	1.2	0.2781
Flat fibers (per 10,000 fibers)	19.7^b	28.0^a	2.3	0.0086
Average fiber curvature (deg/mm)	15.5^a	14.6^b	0.3	0.0356

^{a,b} Means in the same row with different superscripts differ (P < 0.05).

Table 3. Least squares means of expected breeding values, body weights, fleece weights, and fiber properties for high and low juniper-consuming 2006-born female and male Angora kids (approximately 12 months of age at time of shearing).

Item	High (33)	Low (43)	SED	*P*
Expected breeding value (% juniper consumption)	3.9[a]	-0.4[b]	0.5	< 0.0001
Body weight (kg)	21.8	22.7	0.9	0.3764
Grease fleece weight (kg, adjusted to 182.5 d)	2.2	2.1	0.2	0.7054
Clean yield (%)	82.0	80.2	1.0	0.1279
Clean fleece weight (kg, adjusted to 182.5 d)	1.8	1.7	0.1	0.5110
Clean mohair per unit BW (g/kg)	86.2	77.6	7.8	0.3085
Lock length (cm, adjusted to 182.5 d)	14.2	14.1	0.6	0.9070
Average fiber diameter (µm)	29.8	29.0	0.6	0.2389
Opacity (%)	51.2	51.2	0.4	0.8926
Total medullation (per 10,000 fibers)	91.2	101.4	8.6	0.2729
Objectionable fibers (per 10,000 fibers)	12.8	18.8	3.4	0.1261
Flat fibers (per 10,000 fibers)	42.9	41.0	4.4	0.6827
Average fiber curvature (deg/mm)	17.7	18.4	0.6	0.2757

[a,b] Means in the same row with different superscripts differ ($P < 0.05$).

Table 4. Least squares means for extreme high and low juniper-consuming male yearlings completing an annual central performance test concluding in 2005 through 2007.

Item	High (33)	Low (32)	*P*
Expected breeding value (% juniper consumption)	3.4[a]	-1.7[b]	< 0.0001
Initial weight (kg)	25.5[b]	27.9[a]	0.0028
Final weight (kg)	53.8[b]	57.9[a]	0.0107
Body average daily gain (kg/d)	0.2	0.2	0.5904
Grease fleece weight (kg, adjusted to 182.5 d)	4.9[b]	5.4[a]	0.0232
Clean yield (%)	74.1[a]	71.1[b]	0.0048
Clean fleece weight (kg, adjusted to 182.5 d)	3.7	3.8	0.2626
Average lock length (cm, adjusted to 182.5 d)	17.3	17.3	0.9221
Average fiber diameter (µm)	36.5	37.5	0.1366
Med content (%)	0.7	0.9	0.0528
Kemp content (%)	0.1	0.2	0.0775
Scrotal circumference (cm)	27.8[b]	28.9[a]	0.0473

[a,b] Means in the same row with different superscripts differ ($P < 0.05$).

Table 5. Mean values for extreme high and low juniper-consuming males used as primary stud goats in the 2007 breeding season measured during a central performance test.

Item	High (3)	Low (3)	*P*
Expected breeding value (% juniper consumption)	6.2[a]	-2.4[b]	< 0.0001
Initial weight (kg)	21.0[b]	30.1[a]	0.0280
Final weight (kg)	48.7	54.9	0.1267
Body average daily gain (kg/d)	0.2	0.2	0.5965
Grease fleece weight (kg, adjusted to 182.5 d)	4.8	5.1	0.4305
Clean yield (%)	73.5[a]	66.1[b]	0.0422
Clean fleece weight (kg, adjusted to 182.5 d)	3.5	3.4	0.4568
Average lock length (cm, adjusted to 182.5 d)	16.1	16.3	0.6670
Average fiber diameter (µm)	34.1	37.2	0.2569
Med content (%)	0.6	1.2	0.0781
Kemp content (%)	0.2	0.2	0.5777
Scrotal circumference (cm)	29.0	29.4	0.7995

[a,b] Means in the same row with different superscripts differ ($P < 0.05$).

Perhaps the best indicators of future trends are the data for extreme males and particularly that of the 6 goats that were used to breed in 2007. Data collected during the central performance tests (Table 4) indicate the extreme high males are smaller, higher yielding, and grow similar amounts of clean mohair compared to the low consumers. The same trends are present for the 2007 stud billies (Table 5) although conclusions should not be drawn from such small samples (n=3 per line). At this point during the selection experiment (still early days), the only real cause for concern is the lower body weights of the high-consuming goats. Clean mohair production was not reduced and no major differences were present in the mohair quality traits. To date, much of the genetic progress to increase juniper consumption can be traced to one sire present in the 2003 source population. Therefore, much of the line effect may be due to this sire. Because creation of increasingly divergent lines was our primary goal, little attention to date has been paid to the consequences of inbreeding. Nevertheless, it is a concern and we will be maintaining our search for alternative genetic sources of high juniper-consuming Angora males.

CONCLUSIONS

Fecal sampling procedures and fecal NIRS equations have been developed that have permitted us to clearly distinguish high and low juniper-consuming Angora goats and accurately estimate the relative amounts of juniper in their diets. A recently concluded study provided evidence of a physiological difference in bioavailability of monoterpenes between high and low juniper-consuming goats. Once the mechanism of action is understood, we will attempt to identify a genetic marker associated with the trait that will aid in identification of high juniper-consuming goats in the flocks of other breeders. At this early stage of the selection program, no substantial differences in mohair production or quality have been observed and certainly none that would have an economic impact for producers. Ultimately, we expect to demonstrate that the high-consuming line controls juniper more effectively than either the low line or unselected Angora goats. Subsequently, we plan to release high juniper-consuming genetics to commercial breeders for use in range management. These goats will benefit landowners not only through brush control but also through their conversion of unutilized and undesirable brush species to meat and fiber.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge funding for this project from USDA, CSREES (Special Grants and Joe Skeen Institute for Rangeland Restoration), the Binational Agricultural Research and Development Fund, and the Texas Department of Agriculture, Food & Fibers Research Grant Program.

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Submitted June 09, 2008 – Accepted January 30, 2009