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Diet Botanical Composition of Goats on Rangeland Treated with Trenbolone Acetate

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Abstract: An experiment was conducted to examine how Trenbolone Acetate (TBA, 33 mg)/estradiol-17β (E_2, 5 mg) implant affect diet selection of pluriparous mixed-breed goats (n = 10 per treatment) grazing in a highly degraded microphyll desert scrub of northern Mexico. Diets of goats were examined using microhistological fecal analysis during the peack growth of forages (August-October). TBA-E_2 caused a 48% increase ($p<0.01$) in daily weight gain of goats. Woody plants were the main component of goat diet with no differences between implanted and nonimplanted goats (64±7 vs. 65±8% across months of study). Differences between diets of implanted and nonimplanted goats were mainly an increase ($p<0.01$) in *Acacia farnesiana*, *Agave lechuguilla* and *Larrea tridentata*. Also, the implanted goats used more ($p<0.01$) forbs than nonimplanted goats. Results indicated higher proportions of both highly palatable and unpalatable forages in the diet of the TBA-E_2 implanted goats compared with control goats which suggests that the administration of these anabolic compounds for an extended period of time modifies food selection of goats in this xeric landscape.

Key words: Microhistological analysis, diet selection, growth rate, botanical composition, landscape, estradiol

INTRODUCTION

Goats on desert rangelands select diets from a diverse array of forage species that vary in kinds and concentrations of nutrients, spines and secondary compounds and meet their nutritional requirements according to their physiological state, body energy reserves, age and landscape characteristics (Mellado *et al*., 2003; Provenza and Villalba, 2005). Diet selection is a multifaceted issue where animal's genetic, early foraging experiences and perhaps artificially altered metabolic state can modify dietary habits. Thus, the internal state of an animal is not static but dynamic, so that changes in its internal state will be followed by an appropriate modification of its feeding behavior which for animals that feeds on more than one food, it might also be necessary to include new foods in its diet (Kyriazakis *et al*., 1999).

When animals are implanted with various anabolic agents that combine androgenic compounds such as Trenbolone Acetate (TBA) with natural estrogenic steroids such as estradiol-17β (E_2), a greater rate of gain (Scheffler *et al*., 2003) and feed efficiency (Berthiaume *et al*., 2006) occurs. These metabolic modifiers also increase plasma concentration of thyroxine (Mader and Kreikemeier, 2006), IGF-I (Johnson *et al*., 1998), plasma urea nitrogen (Mader and Kreikemeier, 2006) and increase in muscle IGF-I mRNA (Kamanga-Sollo *et al*., 2008).

Thus, it is hypothesized that growth promotants change food habits in grazing goats in order for these animals to regulate their homeostatic state as a result of an increased rate and efficiency of muscle growth. No data are available regarding effects of anabolic agents on food habits of grazing goats. The objective of this experiment was to assess food selection responses of adult goats on rangeland treated with trembolone acetate implants.

MATERIALS AND METHODS

Study site: The experiment was conducted during August, September and October in a microphyll desert scrub area of northern Mexico (25°07'N, 101°40'W; altitude 2150 m). Mean annual temperature is 16°C and average annual precipitation is 299 mm with 75% falling from June-October. The predominant shrubs in this zone are creosotebush (*Larrea tridentata* (DC) Coville), tarbush (*Flourensia cernua* DC.), lechuguilla (*Agave lechuguilla* Torr), pricklypear (*Opuntia rastrera* Weber.), huizache

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(*Acacia farnesiana* (L.) Willd.), sacahuista (*Nolina microcarpa* S. Watson), sotol (*Dasylirion cedrosanum* Trel) and mariola (*Partheniun incanun* Kunth). The main perennial grasses are sideoats grama (*Bouteloua curtipendula* (Michx.) Torr.) and buffalo grass (*Buchloe dacyloides* (Nutt.) Engelm). The most common forb species are globe-mallow (*Sphaeralcea angustifolia* (Cav.) D. Don.) and silver-leaf nightshade (*Solanum elaeagnifolium* Cav.). Historically, this communal pasture has been heavily stocked and continuously grazed by large herds of goats, bovines and equines. Mean aboveground standing crop at the beginning of the study, estimated with 29 m^{-2} paddocks randomly scattered in the pasture was 2021 kg ha^{-1}.

Goat management: A subset of twenty mature, nonpregnant and non-lactating goats of undefined genotype (Criollo x European Dairy goats) were selected from a large commercial flock of goats (n = 250). The goats were randomly assigned into two groups: non implanted (n = 10) and implanted subcutaneously with 1/6 of Synovex-plus® (Fort Dodge Animal Health) used for beef cattle which was equivalent to 33 mg trenbolone acetate/ 5 mg E_2 (n = 10) during 98 days. Goats were weighed at 14 day intervals using a platform scale and a weighing crate. The goats weighed 30.3 (SD 2.6) kg at the beginning of the study. Body condition score was assessed by palpating the sternum and lumbar area using a 1-5 scale (lean to obese).

Goats grazed driven by a herdsman during 8 h daily (1000-1800 h) and were penned from 1800-1000 h with no extra food or salt supplementation. Goats spent the night in unroofed corral and had access to water only once a day. Goats were not subjected to an anthelmintic drenching program. Grazing constraints related to diet selection were considered nonexistent because animals were taken to different grazing sites every day and goats walked about 5 km from the pen. These grazing patterns allowed free choice among existing plant species.

Diet analysis: Fecal samples (approximately 10 pellets per animal) were collected from the rectum of goats in August, September and October. During each month, fecal samples were collected from each goat on 5 consecutive days. The same goats were used in each sampling period. The fecal samples were dried at 50°C in an oven for 72 h and then ground in a Willey mill to pass a 1 mm mesh screen. The samples were bulked thoroughly mixed and mounted in five slides for further analysis with a compound, phase-contrast microscope until 100 fragments of plants were identified. Botanical composition (identified to species level) of goat diets was determined using the microhistological technique described by Sparks and Malechek (1968). Before fecal collection, test slides were prepared for all plants species present in the study area in order to properly identify plant fragments.

Statistical analyses: Growth performance differences for implanted and nonimplanted goats were tested by one-way analysis of variance using the GLM procedure of SAS (SAS institute, Cary, NC):

$$Yij = \alpha i + E_{ij}$$

Where α_i is treatment effect (i = 1 or 2) and Eij, the residual standard deviation used as the error term. Individual goats were considered the experimental units.

The effect of trenbolone acetate implants on botanical composition of diet was evaluated with a mixed-modeling approach (PROC MIXED; SAS software version 9.1, 2001; SAS institute, Cary, NC) with two-factor repeated-measures analysis with implant as an independent continuous cross-classification factor and time as the repeated factor. The interaction term was included to assess whether the effect of implant was consistent over time. Animal was treated as a random effect whereas all other terms were treated as fixed effects. Where significant differences occurred, Scheffe's test was used to separate the means. Percentage data were arcsine-square root transformed prior to analysis.

RESULTS AND DISCUSSION

Growth performance: During the peack growth of forages, the TBA-E_2 implanted goats gained more weight than did control goats (71±12 vs. 48±10 g day^{-1}; p<0.01) which resulted in heavier weights for implanted goats at the end of the trial (Fig. 1). Body condition score was not changed in the treated and untreated animals (2.0 vs. 1.9;

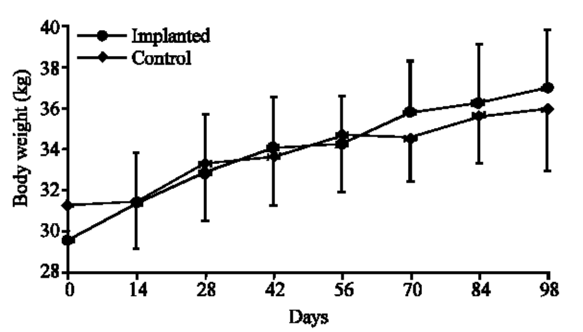

Fig. 1: Accumulated weight gain of implanted and nonimplanted (control) mature nonlactating goats grazing on a microphyll desert scrub of northern Mexico. Points are means±SD

five point scale) which was expected as growth implants produce leaner carcasses (Reiling and Johnson, 2003). In cattle treated with exogenous sex steroids, average daily gain has been increased 8-20% depending on the sex, implant strategy and duration of feeding (Anderson, 1990). In the present study, the weight gain elicited by the TBA-E_2 implants was 48% which is far greater than that found by other researchers.

However, increase in average daily gains as high as 29% has been observed in implanted steers in winter grazing programs (Paisley *et al*., 1999). These differences in responsiveness to anabolic compounds may be explained by the extremely thin condition of goats at the beginning of the study.

In fact, goats in the present study were catabolic at the beginning of the trial as indicated by low weight and reduced external adiposity scores. Moreover, TBA-E_2 has been tested mainly in well-fed young animals slaughtered when they reached a small degree of marbling or a constant weight or time end point.

The greater weight gain exhibited by the implanted goats was probably due to increased protein deposition and reduced maintenance but not due to a greater feed intake because TBA-E_2 increases weight gain with little effect on feed ingestion (Henricks *et al*., 1997). This increased weight gain in implanted ruminants is attributed to improved metabolic efficiency by decreased maintenance energy requirements (Hunter and Vercoe, 1987) and decreased muscle protein degradation (Bohorov *et al*., 1987) rather than to an increased feed intake (Kreikemeier and Mader, 2004).

Botanical composition of goat diet: The diet selected by the implanted and nonimplanted goats is shown in Table 1. With the TBA-E_2 implant subtle differences in food selection became evident, goats began to use a higher proportion ($p<0.01$) of the highly nutritious shrub *Acacia farnesiana* than control goats. This leguminous shrub was one of the most consumed species by implanted goats during August and September. During this time of the year the proportion of this leguminous shrub made up 15% of the diet of the implanted goats. This woody browse differ from other *Acacias* species in the study zone in that it contains >15% crude protein year-round, a low content of condensed tannins (Ramirez *et al*., 1999) and exhibits a rapid rumen degradability of the dry matter and crude protein (Ramirez and Lara 1998; Ramirez *et al*., 1999) which makes this shrub a good forage for grazing ruminants.

As conditions became less humid (October) there was a noticeable reduction ($p<0.01$) in the use of *Acacia farnesiana* by implanted and control goats. Another feature of the diet of the implanted goats was the higher percentage of *Agave lechuguilla* in September compared to control goats Table 1. This agavaceae is a highly fibrous plant but apparently during the active growth (summer) the tips of this plant offer a nutritional advantage to goats because this agavaceae makes up an important proportion of goat diets in this landscape (Mellado *et al*., 1991, 2004a), despite its toxicity in domestic goats (Dollahite *et al*., 1962). Goats seems to avoid toxicity of this plant by selectively eating only the tips of blades after eliminating the stout, sharp, terminal

Table 1: Average percentage (mean±SD) of plant species identified in seasonal diets of implanted (33 mg trembolone acetate+5 mg estradiol) and nonimplanted goats grazing in a microphyll desert scrub pasture

	August		September		October	
Species shrubs	Implant	Control	Implant	Control	Implant	Control
Acacia farnesiana	11.9±4.4^a	13.3±3.9^a	14.4±4.1^a	1.7±1.9^b	0.7±0.9^a	1.9±1.8^a
Agave lechuguilla	0.0±0.0^a	0.5±0.5^a	8.4±2.8^a	3.3±2.3^b	2.2±1.5^a	2.5±1.5^a
Berberis trifoliolata	5.7±2.2^a	4.4±1.7^a	7.3±3.2^a	11.1±3.6^b	11.3±3.6^a	12.8±3.1^a
Cowania plicata	1.0±0.3^a	2.4±1.1^b	2.6±1.1^a	3.5±0.3^b	3.3±1.1^a	4.6±1.6^a
Larrea tridentata	6.8±2.5^a	2.4±1.4^b	7.8±1.7^a	10.4±3.6^a	9.5±3.2^a	8.0±3.0^a
Lindleya mespiloides	13.9±5.0^a	13.2±4.7^a	12.2±3.5^a	10.6±6.9^a	15.7±3.3^a	16.3±3.2^a
Nolina cespitifera	4.3±2.2^a	5.1±2.5^a	4.0±2.1^a	5.9±2.6^a	6.1±3.0^a	6.6±3.0^a
Opuntia rastrera	1.1±0.6^a	2.6±1.3^b	8.2±5.7^a	10.0±6.4^a	3.9±3.1^a	4.2±3.2^a
Rhus microphylla	3.3±1.9^a	2.3±1.9^a	4.7±2.3^a	11.6±3.6^b	4.4±2.1^a	4.8±1.9^a
Other shrubs	7.6	5.8	3.2	8.1	6.4	5.9
Total shrubs	55.6±6.4^a	52.5±5.5^a	72.8±4.8^a	76.2±9.6^a	63.5±10.5^a	67.6±8.3^a
Forbs						
Sida abutifolia	5.9±3.2^a	4.3±2.6^a	1.9±1.4^a	2.6±1.7^a	1.7±1.2^a	1.0±0.7^a
Solanum elaeagnifolium	4.7±2.2^a	1.8±1.7^b	1.4±1.3^a	1.9±1.3^a	5.3±3.2^a	3.0±2.1^a
Sphaeralcea angustifolia	4.8±3.0^a	3.6±2.0^a	3.4±2.0^a	1.4±0.9^b	4.4±2.7^a	1.1±0.6^b
Other forbs	1.6	1.9	0.9	2.8	1.2	1.9
Total forbs	17.0±2.3^a	11.6±2.9^b	7.6±3.1^a	8.7±1.6^a	12.6±3.2^a	7.0±1.8^b
Grasses						
Bouteloua gracilis	5.4±2.6^a	10.9±3.0^b	4.9±2.5^a	2.3±1.7^b	4.8±2.1^a	7.8±6.8^b
Buchloe dacyloides	5.9±3.0^a	4.7±2.1^a	5.0±2.4^a	3.0±1.8^a	8.8±2.3^a	4.2±2.3^b
Lycurus phleoides	11.0±3.8^a	10.6±3.2^a	5.7±2.3^a	3.8±2.6^b	4.8±2.7^a	6.9±2.4^b
Muhlenbergia repens	4.5±2.2^a	7.2±3.5^b	3.5±2.0^a	5.6±1.4^b	2.9±1.3^a	3.7±0.3^a
Other grasses	0.6	2.5	0.5	0.4	2.6	2.8
Total grasses	27.4±2.9^a	35.9±6.1^b	19.6±5.8^a	15.1.1±3.0^b	23.9±2.3^a	25.4±2.1

^{a,b}For each month, means within a row lacking a common superscript letter differ ($p<0.01$)

spine. It is clear that the saponins of this plant do not cause gastrointestinal distress or the gastrointestinal consequences are overridden by positively rewarding effects which makes goats not to become aversive to this forage. Among individual plant species identified as large constituents of the goats diets was *Berberis trifoliolata*. The implanted goats made a lower ($p<0.01$) use of this spiny and coarse shrub during September than control goats. The foliage of this shrub has needle-sharp tips which make this forage not desired for deer (Armstrong *et al*., 1991). Apparently, goats sought out this plant because of the sparse vegetation this use was of interest because *Berberis trifoliolata* is considered unimportant livestock forage.

Percentages of the unpalatable shrub *Larrea tridentata* in the diet of both implanted and control goats were relatively constant throughout the study period although, in August, implanted goats ate a higher proportion of *Larrea tridentata* than control goats. This resinous shrub is renowned for its toxic secondary chemistry (Hyder *et al*., 2002) and in this type of vegetation, this shrub is generally considered undesirable livestock forage. Despite its poor dietary preference, this shrub was eaten in substantial quantities by goats, hence it seems that heavy communal grazing pressure and low phytomass cover forced goats to consume higher quantities of this shrub than levels previously reported in goats in this landscape (Mellado *et al*., 2003).

Regardless of treatment, the evergreen shrub *Lindleya mespiloides* made up the majority of goat diets throughout the study period. These results are not consistent with the general findings of other studies (Mellado *et al*., 2006a, b) regarding the limited use of this forage by goats.

Opuntia rastrera was a major dietary component of the implanted and nonimplanted does during September but no differences were found between the implanted and control goats during the study period. This reaffirms that spines do not impede goats to consume pricklypear and no health issues derive from its ingestion. Apparently, low protein content of this spiny species (Guevara *et al*., 2009) seems to impede greater use of *Opuntia rastrera* by goats although, this cactaceae is valuable and consistent dietary component of goats in this habitat (Mellado *et al*., 2004b, 2006).

Contrary to other studies where forb intake exceed that of browse during the wet summer in this landscape (Mellado *et al*., 1991, 2003), the proportion of forbs in this study did not exceed 17% of the diet. Independently of treatment, shrubs dominated the diet of goats throughout the study period. Thus, browse provided the base of the diet while forbs and grasses were used opportunistically.

Also, contrary to other studies in this type of vegetation (Lopez and Stuth, 1984; Mellado *et al*., 1991) browse was not utilized in greatest quantity by goats at the high of the dry season when green grasses and forbs are sparse, rather, browse was heavily used during the rainy season. This response is simply explained by the scarce forage resources after decades of over-grazing in this communal pastoral zone and the succulence and nutritional levels of some of the shrubs selected by goats.

The implanted goats used more ($p<0.01$) forbs in August and October than nonimplanted goats. It is not known if the different diet composition of implanted goats altered diet quality but given that concentration of nutrients in most forbs of the Chihuahuan desert exceed the nutritional requirements of ungulates (Soltero-Gadea *et al*., 1994), it could be that the nutrient density of the diet of the implanted goats was higher than the control goats. The major forb selected by both implanted and nonimplanted goats was *Sphaeralcea angustifolia* with higher percentages ($p<0.01$) of this herb in the implanted goats in September and October. The high levels of this forb in the goat diets is explained by its low concentration of secondary compounds, high nutrient levels, high digestibility of nutrients and high intake which makes this forb comparable to alfalfa (Mellado *et al*., 2008b).

The high use of this forage by goats in desert rangelands has been amply documented (Mellado *et al*., 2004a). Another important forb in the goat diets was *Solanum elaeagnifolium*, a highly unpalatable forage (Mellado *et al*., 2008a) which was ingested in greater proportion in August by the implanted goats compared to control goats. This indicates that selectivity for this forb was in response to the shortage of forage rather than its nutritional quality. Despite its high unpalatability, this forb is a staple food for goats in degraded xeric ecosystems (Mellado *et al*., 2003, 2004b, c).

During August grasses were used more heavily ($p<0.01$) by the control goats than the implanted goats but this tendency was reversed in September. The heavy grass usage in August apparently was the result of forced utilization caused by shortage of browse. Lopez and Stuth (1984) have reported that goat preference for grasses was inversely associated with brush availability. The nonimplanted goats consumed higher ($p<0.01$) proportions of *Bouteloua curtipendula* than the implanted goats in August and October. On the other hand, the implanted goats selected twice as much ($p<0.01$) Buchloe dactyloides in October than control goats.

Regardless of implant treatment, *Lycurus phleoides* was consistently the grass with the highest selection throughout the study period. This grass is one of the most ingested by cattle in this landscape (Chavez *et al*., 2000). The quantity of grass ingested by goats in this study is much higher than levels reported by other researcher in this type of vegetation (Mellado *et al*., 1991; Lopez-Trujillo and Garcia-Elizondo, 1995). But Warren *et al*. (1984) and Bryant *et al*. (1979) found high use of grass by Spanish goats (around 50% of diet) in spring in this type of vegetation under excellent condition.

CONCLUSION

The results of this study show that implanting mature nonlactating thin goats during the peak growth of forages improved weight gain an average of 48% despite having daily gains <70 g day^{-1}. TBA-$E_2\beta$ implants led to divergent diet selection which suggests that goats alter their diet choice in an attempt to adjust to short-term systemic fluctuation of their internal environment brought about by growth implants. Implications of this study are commercial and ecological because implants with trenbolone acetate during the active growth of forages can increase muscle mass in even thin goats and it helps spread grazing pressure onto low quality plants that are underutilized.

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