

Seasonal Changes in Chaparral Composition and Intake by Spanish Goats¹

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Browse may contribute a major portion of goat's diet (Davis and others 1974, Wilson and others 1975). Reports on diet selection by goats in different regions of the world (McCammon-Feldman 1980) suggests a great variation in feeding habits of goats in different ecological zones. According to Coblenz (1977) and Kay and others (1980), goats are adaptable mixed feeders rather than browsers.

The objectives of this paper were to study the seasonal variations in intake, digestibility and composition of a recently burnt chaparral community by Spanish goats. Correlations between these variables were examined. The response of consumption to availability and its effect on grazing strategies by goats are discussed.

MATERIALS AND METHODS

Site Description--This study was conducted in a chaparral community burnt June 1978 at Hopland Field Station located on the southeastern part of Mendocino County of the northern coastal area of California (Latitude 39°N, Longitude 123°W). The climate is mild with rainy winters and dry summers. Mean annual rainfall is 112.0 centimeters.

Immediately after burning, the area (3.2 ha) was enclosed by a deer proof fence. Five 0.20

¹Presented at the Symposium on Dynamics and Management of Mediterranean-type Ecosystems, June 22-26, 1981, San Diego, California.

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Abstract: Seasonal changes in utilization of one year regrowth of chaparral by Spanish goats was investigated. Esophageal and fecal samples were obtained during spring, summer and fall of 1979. Preference of Spanish goats was highly directed towards oak (50%) and chamise (30%) in all seasons. Correlation of use and availability indicated that goats may be generalist but select between the dominant species. Tannins were at low concentrations and did not appear to be affecting utilization. Predictive equations for intake and digestibility were derived. Recently burnt chaparral provides a maintenance diet for Spanish goats during spring and summer only.

to 0.26 ha plots were constructed inside the fenced area and one of these (0.26 ha) was chosen to conduct the seasonal study reported in this paper. This plot was dominated by four shrub species and a very thin cover of some grasses and forbs. Initial vegetation composition (% cover) was measured at the beginning of each sampling period using the line-intercept technique as described by Cox (1972). Cover measurements represented the spread of the twigs (with or without leaves) over the soil surface (Table 1). The shrub species in order of dominance during the spring season measurement were chamise (Adenostoma fasciculatum), oak (Quercus dumosa and few Q. wislizenii), manzanita (Arctostaphylos glandulosa), and ceanothus (Ceanothus cuneatus and Q. foliosus).

Forage yield was not measured on the seasonal study plot. The regression of cover on yield (kg DM) measured on four adjacent plots was highly correlated ($P < .001$) and justified our use of cover as an index of availability. Daily temperature means during sampling were 19, 18 and 12°C for the spring, summer and fall periods respectively.

Table 1--Mean percentage cover during spring, summer and fall seasons.

	Spring	Summer	Fall
Oak	10.5	11.7	4.5
Chamise	10.9	11.5	9.2
Manzanita	1.1	1.3	0.5
Ceanothus	1.1	1.4	1.6
Green herb	7.6	0.2	0.4
Dead herb	0	2.5	0
Dead shrub leaves	0	3.6	4.4

Animals and Sampling Procedure

Eight esophageal fistulated Spanish goat wethers (1 to 2 years of age purchased from Southern California and weighing 23.4 ± 2.6 kg) were used in a grazing trial to collect dietary and fecal samples during spring, summer and fall of 1979. Winter grazing trial was not conducted as the site (985 m elevation) was considered unsuitable for grazing activity during the cold months. Prior to sampling, the animals were adapted to the vegetation by grazing for 10 days inside the experimental plots. All animals were drenched for internal parasites at approximately seven week intervals during the study. Daily samples were collected in the following sequence: 15 days in each of the spring and summer seasons (June 4-19 and August 21 - September 4), and for 12 days in fall (October 8-20). The fall trial was terminated 3 days earlier than scheduled because of cold and stormy weather.

Four goats were used for each seasonal study (Table 2). Goats were confined overnight prior to daily fecal collection at 0700 hr which was followed by a 1 to 2 hr collection of esophageal fistula samples. Once diet samples were collected, the fistulae were closed and the goats were left to graze until sunset. Drinking water, salt and dicalcium phosphate were made available ad libitum in the holding pen and in the experimental plot.

Table 2--Live weight of goats and sample collection schedule.

Season	Animal #	Sample Count	Live weight (kg)	
			Initial	Final
Spring	1	5	20.4	24.0
	2	5	22.9	22.7
	3	5	24.0	24.9
	4	5	24.3	23.8
Summer	4	5	23.4	23.1
	5	4	23.4	23.1
	6	5	28.1	23.6
	7	5	24.0	23.6
Fall	3	4	23.1	16.3
	5	4	25.0	19.0
	7	4	24.5	19.5
	8	4	17.2	15.4

¹Count: a unit represents compounded average of 3 days collection (feed or feces) by the same animal.

Leaves and twigs of young regrowing green shoots were clipped at the middle of each seasonal grazing period. These clipped samples,

together with esophageal samples, were frozen, freeze-dried and ground in a wiley mill (1 mm screen) preparatory to analysis. The fecal samples were oven dried at 55°C and moisture contents were recorded.

Analytical Procedures

Diet samples collected from each animal over a 3-day period were compounded in equal proportions. Rumen contaminated samples were excluded. Five composited dietary samples per goat were obtained to represent spring and summer periods and four samples per goat for the fall (Table 2). From each compounded sample, as well as from the clipped shrubs, microscopic slides were prepared for microhistological identification (Sparks and Malecheck 1968). Use was calculated as the % of each species in fistulae samples on a dry matter basis. Kjeldahl nitrogen (N) was measured by the AOAC (1975) procedure. Esophageal and clipped samples were incubated with rumen liquor collected from a donor goat fed 65% shrub and 35% alfalfa hay feed mixtures in order to estimate in vitro digestibility values (Tilley and Terry 1963). Fiber components and tannins were estimated by the sequential detergent system (Van Soest and Robertson 1980). The clipped samples were analyzed similarly, and a further parallel sequential analysis to estimate tannins and cutins was performed based on the method described by Horvath (1980) with modifications of Van Soest (personal communication). Intake (I) was calculated by dividing average daily fecal dry matter output (F) for samples collected in either 3 or 6 days over the apparent indigestible coefficients (Ra) obtained in vitro for dietary samples; $I = F/Ra$. Statistical analyses were performed using the methods described by Steel and Torrie (1960).

RESULTS AND DISCUSSION

Dietary Botanical Composition

Botanical composition of the esophageal samples for each season are shown in Table 3. There was no significant change in dietary preference with seasons ($P > .1$). Oak comprised over half the diet in all three seasons, followed by chamise (35% of the dry matter). The selective behavior of the goats was examined by correlating use and availability (Nudd 1980, Westoby 1980). Use (% in the diet) for the 4 shrub species was significantly associated ($r = .85$, $P < .005$) with availability (Tables 1 and 3). This relationship may imply a generalistic strategy where resources are restricted and fitness is attained by maximizing energy intake (Schoner 1971). Within the esophageal samples there was a reciprocal relationship between oak and chamise ($r = -.89$, $P < .005$) as shown in figure 1. Use was poorly associated with availability ($r = -.13$) when oak and chamise were

Table 3--Mean]. percentage botanical composition of esophageal samples.

Season	Oak	Chamise	Manzanita	Ceanothus	Others
Spring	57±4	34±3	1±1	1±1	6±2
Summer	59±4	35±3	3±1	2±1	1±1
Fall	51±4	38±4	6±2	4±1	1±1
Mean of all 3 seasons	56±4	36±3	3±1	2±1	3±1

1 ± SE \hat{p} .

considered separately, and preference for oak and chamise coincided with dominance. However, in a previous study (Sidahmed and others 1981a) conducted in southern California, we observed a similar preference for oak and chamise in a plot dominated by manzanita and ceanothus. This suggests that goats exhibit a specialized behavior for oak and chamise.

The herbaceous species were of minor importance both in the plot and in the diet during summer and fall (Tables 1 and 3). In the spring, the diets selected contained about 6% herbaceous species while availability was 7.6%. This finding may suggest that consumption of the herbaceous plants was restricted by availability. But, Westoby (1980) reported that consumption of particular foods was constrained by availability only at cover values below 0.5%.

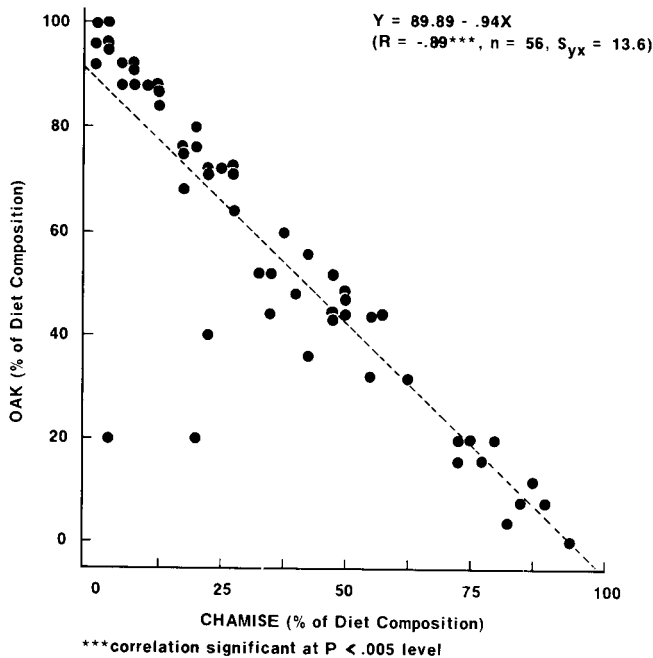


Figure 1--The relationship between the % composition of oak and chamise in esophageal samples collected by goats.

Table 4--Chemical constituents and IVOMD of clipped shrubs.¹

Chemical constituents (%)	Oak	Chamise	Manzani	Ceanothus
CWC	59±4	55±7	41±2	60±4
NAD	42±3	40±4	34±3	46±.9
NADLk	9±.3	8±2	10±1	9±1
Cutin	4±2	7±.8	9±2	7±2
Ash	4±.5	3±.4	3±.4	3±.5
N	1±.4	1±.3	1±.1	1±.2
Tannins	2±.5	4±5	0	2±2
IVOMD	34±5	28±6	30±4	26±5

¹Means ± SD.

See text below for key to abbreviations.

Nutritional Characteristics of Clipped Shrubs

The chemical composition of the shrubs was estimated from samples clipped during each season. Regression of *in vitro* digestibility (IVOMD) on chemical constituents (Table 4) showed positive and linear relationships with nitrogen ($r = .69$, $P < .05$) and ash ($r = .77$, $P < .005$). Although there were negative relationships with fiber components for data pooled from all shrub species ($r = -.41$ to $-.56$), these relations were not significant. Also, it was observed that the correlation coefficients of fiber components in oak and chamise were greater ($r = -.40$ to $-.67$) than in all shrub species. Sequential neutral-acid detergent fiber (NAD) was more closely associated with IVOMD than other fiber components. With herbaceous feeds, Van Soest and others (1978) suggested that acid detergent fiber and lignin depress digestibility more than cell wall content (CWC) or cellulose. Permanganate lignin (NADLk) had an insignificant effect on depression of IVOMD of the shrub samples ($r = -.14$). However, cutin and sulphuric lignin (NADLs) had a more pronounced association ($r = -.41$ and $-.31$, respectively). These correlations suggest that cutin would depress digestibility of shrubs more than true lignin (permanganate lignin). However, Van Soest (1969) suggested on limited data that cutin had a lesser and quantitatively different effect than permanganate lignin on depression of digestibility of sunflower and castor seed hulls.

The difference between acid detergent fiber (ADF) and NAD gives a presumptive estimate of condensed tannins (Van Soest and Robertson 1980). The correlation of ADF-NAD tannins and IVOMD was low for all shrubs and for oak and chamise together ($r = .19$ and $.43$, respectively).

Comparison of clipped versus esophageal samples showed that goats selected a diet higher in digestibility (22-39 versus 39-47%) and N (1 versus 1.47%) than the clipped samples (Tables 4 and 5). However, the association of N with digestibility was higher for clipped samples and fall diets ($r = .69$ and $.77$) than spring and summer diets ($r = .43$ and $.25$, respectively). This indicates either a N limiting effect on digestibility or the high correlation of N with plant age.

Seasonal Changes in Intake and Digestibility

No significant difference ($P > .05$) was observed between intake values estimated from average fecal output of 3 or 6 days. Therefore, intake values based on calculations using 3 days fecal excretion were used throughout the following discussion. Animal-season interactions could not be determined by two-way analysis of variance because of missing cells resulting from replacing goats during the study (Table 2). Therefore, the variation between animals within each season was examined first. From 13 parameters (IVOMD, intake, N, tannins, CWC, NAD, NADC, NADL_s, NADHC, NADL_s:NAD, ash and fecal moisture), there were significant differences between animals in intake during spring and fall ($P < .05$, $P < .001$, respectively) but not in summer. Also, different animals consumed diets containing different N levels ($P < .05$) in summer, and cellulose ($P < .05$) in the fall. It was assumed that between-animal variation was not significant except for intake.

Table 5--Percentage dietary chemical constituents, *in vitro* organic matter digestibility (IVOMD) and fecal moisture content.¹

Dietary constituents (%)	Spring n=20	Summer n=20	Fall n=16	All seasons n=56
IVOMD	47 ± 3 ^a	44 ± 6 ^a	39 ± 5 ^b	43 ± 6
Intake	60 ± 17 ^a	57 ± 11 ^{ab}	36 ± 11 ^c	52 ± 17
N	1.8 ± .2 ^a	1.4 ± .2 ^b	1.2 ± .2 ^c	1.5 ± .3
Tannin (ADF-NAD)	1 ± 1 ^a	2 ± 2 ^a	3 ± 2 ^a	2 ± 2
CWC	46 ± 3 ^a	48 ± 4 ^a	50 ± 6 ^a	48 ± 4
NAD	31 ± 2 ^a	34 ± 3 ^a	36 ± 4 ^b	34 ± 4
NADC	18 ± 2 ^a	19 ± 3 ^a	19 ± 3 ^a	18 ± 2
NADL _s	11 ± 1 ^a	12 ± 1 ^{ab}	15 ± 3 ^c	13 ± 2
NADHC	15 ± 2 ^a	14 ± 1 ^a	15 ± 2 ^a	14 ± 2
NADL _s : NAD	36 ± 4 ^a	34 ± 2 ^a	37 ± 3 ^b	35 ± 4
Ash	10 ± 1 ^a	9 ± 4 ^a	8 ± 3 ^a	9 ± 3
Fecal Moisture	45 ± 2 ^a	46 ± 2 ^a	46 ± 4 ^a	45 ± 3

a, b, c. Means with different superscripts are significantly different ($P < .05$ - $P < .001$).

¹ ± SD.

Seasonal means of intake, digestibility and chemical composition of diet samples, and results of the paired t-test comparisons are summarized in Table 5. Daily feed intake ($g DM/BW^{.75}$) during spring and summer was significantly ($P < .005$, $P < .01$, respectively) higher than during fall. Spring and summer intakes (Table 5) were comparable to the NRC (1975) requirements for sheep, and to recorded values for Spanish goats in a digestion trial (Sidahmed and others 1981b). The reduction in intake from 2.7% of body weight during spring and summer to 1.7% during the fall period was reflected in more than 20% decline in live weight (Table 2). Similarly, IVOMD and N in esophageal samples declined from 47% in the spring to 39% in the fall and from 1.76% to 1.23%, respectively. Also, there was a significant increase in NADL_s of diet samples as seasons advanced. It was suggested that decreasing N and increasing lignin-cutin levels in browse as it matures would contribute to reduction in its utilization by goats. These results agree with conclusions reported by Smith and others (1971) that cellulose availability and rate of cell wall digestion were adversely affected by increase in forage lignin concentrations. There was a nonsignificant increase in dietary ADF-NAD tannins between spring, summer and fall. However, tannin levels were generally low (2%).

Browse Characteristics Related to Intake and Digestibility

Dietary fiber components (CWC, NAD, NADC, NADL_s, NADHC, and NADL_s:ADF ratio), tannins, N, fecal moisture content and mean daily temperature were regressed against intake and digestibility individually (Table 6) and combined in a stepwise analysis.

Predictive equations obtained for intake (DMI) and digestibility (IVOMD) were:

- $\widehat{DMI} = -25.67 + 1.80 IVOMD$
($n=56$, $Sy_x = 17.72$, $r = .59$, $P < .005$).
- $\widehat{IVOMD} = 56.98 - .46 CWC - .45 NADL_s + .65 N + .09 DMI$
($n = 56$, $Sy_x = 2.77$, $r = .88$, $P < .005$).

The correlation between digestibility and intake was significant when all data points ($n=56$) were considered (equation 1). However, when intake and digestibility were regressed individually for each season (Table 6 and Figure 2) the coefficients varied. Intake and digestibility were poorly related in the spring ($r = .13$), but significantly related in summer ($r = .73$) and fall ($r = .45$). It was reported by Lippe (1980) that only when digestibility is closely correlated with factors limiting intake (for example CWC) will it show a high relationship to intake. In this study, digestibility was weakly correlated with fiber components during the spring and highly correlated during

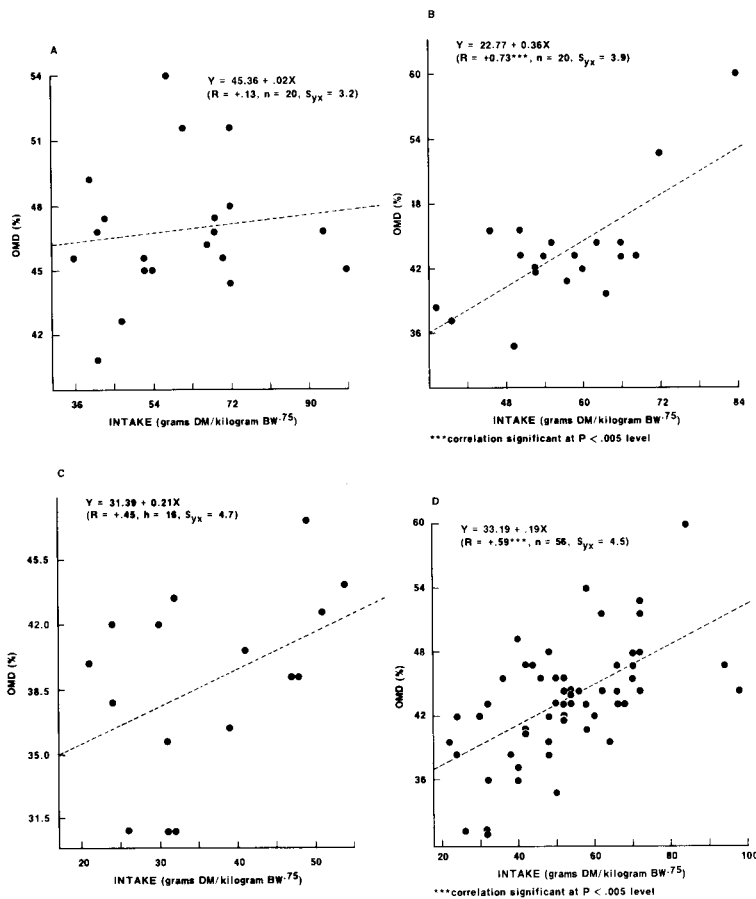


Figure 2. The relationships between digestibility (IVOMD) and intake (a = spring, b = summer, c = fall and d = pooled data points for all three seasons).

summer and fall. The effect of N on digestibility was more significant during fall season and on intake during spring season. The contribution of CWC, NADLs, N and intake to the variation in digestibility of browse diets was 77% (equation 2).

The effect of dietary ash on intake and digestibility was not significant. This contrasted to the strong relationship between ash and digestibility of clipped samples ($r = .77$, $p < .005$). The correlation between intake or digestibility with temperature was positive ($r = .30$ and $.66$, respectively) but not significant. The decline in temperature from 19°C in spring to 12°C in the fall depressed digestibility more than intake. The decline in temperature during the fall was accompanied by storms which restricted the browsing and selection by the goats.

ADF-NAD tannins were poorly correlated with intake (Table 6) and did not exhibit a pronounced effect on digestibility except during the fall ($r = -.66$, $P < .01$). *In vitro* digestibility studies indicated that digestibility was inhibited at tannin levels above 4% (Mika 1978, Horvath 1980). Therefore, low levels of tannin as reported in the present study (2%) would not likely be responsible for the low IVOMD values of the immature shrub diets. The

fecal moisture contents were comparable in all seasons (Table 5) and correlated poorly with intake (Table 6). Similarly, no significant relationship was found between digestibility and fecal moisture. This was in contrast to that reported by Zimmerman (1980) who concluded that high fecal moisture reflects better dietary quality of grazing cattle.

In conclusion, it is suggested that recently burnt chaparral vegetation would provide only a maintenance diet for goats during spring and summer and a submaintenance diet during fall.

ACKNOWLEDGEMENTS

This research comes from a doctoral dissertation for the Department of Animal Science at the University of California, Davis. Partial support was provided by research grants from the Chaparral R&D Program, USDA, Forest Service, and the Institute of Ecology, UCD (OPER-4791). Appreciation is extended to Mr. Al Murphy, Superintendent, Hopland Field Station, for generous assistance and for performing the prescribed burning for the study site. Mr. Norman Hinman helped in statistical analysis, and Mr. John Bryan in laboratory analysis.

Table 6--Relationship between *in vitro* organic matter digestibility (IVOMD), intake and dietary chemical constituents and fecal moisture content.

Dietary constituent (%)	% IVOMD Intake (g/w. ⁷⁵)	
	All seasons n=56	All seasons n=56
IVOMD Intake	1.00	.59***
N	.59***	1.00
Tannins (ADF-NAD) CWC	.65***	.26
NAD	-.50***	-.20
NADC	-.74***	-.45***
NADL	-.75***	-.49***
NADHC	-.54***	-.29*
NADLs: NAD	-.75***	-.46***
Ash	-.43***	-.18
Fecal Moisture	-.24*	-.17
	.15	.15
	-.19	.05

*, **, *** Correlations significant at P<.05, P<.01, P<.005 levels, respectively.

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