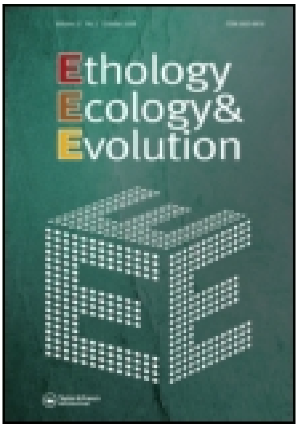

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In cafeteria trials with tannin rich plants, tannins do not modify foliage preference of goats with browsing experience

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It has been suggested that goats with browsing experience might not affect their preference and fodder intake by the tannins contained in tropical browse. To test this hypothesis, polyethylene glycol (PEG 3600 MW), a tannin blocking agent, was used in cafeteria trials employing browses commonly available in their diet. The selectivity (SI), preference and intake rate (IR) as well as the effects of plant density, chemical composition (including tannin content) and PEG supplementation were assessed. Goats showed a low SI, explained as a behavioral adaptation in a tannin rich environment. PEG administration had no effect on the goats' preference or IR. The IR seemed affected by plant densities. Also, fiber components had higher associations with DM intake than the polyphenolic compounds at the levels found in the evaluated forages. It was concluded that tannins and PEG did not modify goats' preference in cafeteria trials. Hence, tannins have a limited involvement in short term preference regulation of goats with browsing experience.

KEY WORDS: selectivity, plant secondary compounds, fiber, small ruminants, intake.

INTRODUCTION

The domestic goat is an herbivore which has shown an ability to adapt its feeding behaviour to the chemical characteristics of food, selecting plants according to

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their nutritive quality (BARAZA et al. 2009). In some tropical areas most tropical trees and shrubs browsed by goats have relatively high levels of plant secondary metabolites (PSM) (MONFORTE-BRICEÑO et al. 2005; ROSSI et al. 2007; TORRES-ACOSTA et al. 2008). Those PSM, specifically condensed tannins (CT), have been reported as modulators of the intake of single feed under controlled conditions, since CT in large quantities seems to reduce intake (HOSTE et al. 2006). The role of condensed tannins in feed preference during short term cafeteria experiments has been challenged in goats and sheep with browsing experience (ALONSO-DÍAZ et al. 2008, 2009a, 2009b). Instead, both fibre components and foliage density have been suggested to be involved in the regulation of intake (ALONSO-DÍAZ et al. 2008, 2009a, 2009b). Goats usually eat the browse fodder and it has been suggested that they have developed strategies, such as tannin binding salivary protein, to cope with the tannin contained in the browse (VAN SOEST 1994; ALONSO-DÍAZ et al. 2012) in a similar manner as other mammalian herbivore species (MOLE et al. 1990). As a result, when a diversity of forages is available, goats show no differential selection and widespread consumption of forages of variable quality (ALONSO-DÍAZ et al. 2008, 2009a; BARAZA et al. 2009). Thus, we hypothesized that adding a tannin blocking agent such as polyethylene glycol (PEG) into the diet would not affect the animal's preference and selectivity. The use of PEG would allow confirmation of the limited role of CT content in the browse as a limiting factor in foliage preference of goats. Therefore, the objective of the present study was to evaluate the relationship between chemical composition, selectivity index (SI), preference and intake rate (IR) of tanniniferous forage trees offered in cafeteria experiments to goats with and without PEG supplementation.

MATERIAL AND METHODS

Study area

This work was carried out at the Faculty of Veterinary Medicine and Animal Science, Universidad Autonoma de Yucatan (FMVZ-UADY). The climate of the area is tropical, subhumid with summer rainfalls. Average temperature varies from 26–27.8 °C and annual rainfall ranges from 940–1100 mm (GARCÍA 1988).

Experimental forages

Fresh leaves of *Havardia albicans, Acacia gaumeri,* and *Leucaena leucocephala* were harvested daily in the morning. these plants are common within the native vegetation of the region (FLORES-GUIDO 2001) and have been reported as legumes with high contents of polyphenolic compounds, tannins in particular (AYALA-BURGOS et al. 2006; DÍAZ-ORTEGA et al. 2006). another plant fodder, *Brosimum alicastrum*, which has been reported as being preferred by cattle (SANDOVAL-CASTRO et al. 2005) and with low concentration of condensed tannins (AYALA-BURGOS et al. 2006), was also included in the study. plant samples were collected for identification at the FMVZ-UADY herbarium.

Experimental animals

Ten female Criollo goats (initial average weight of 16.9 kg ± 0.71) were used in preference experiments. All the animals had 8 months of browsing experience in the native deciduous tropical forest of the area and were drenched with an effective wide spectrum anthelmintic three days prior the first adaptation period.

Preference experiment 1

Animals were divided into two groups (n = 5): with and without the addition of PEG (MW 3600, Sigma Co. TM). Each goat received 15 g of PEG diluted in water (1:1 w/v) dosed directly into the mouth 2 times daily: before and 30 min after offering fresh leaves (Silanikove et al. 2001).

Animals were allocated to individual pens (3 × 3 m). Each animal was fed fresh chopped grass (*Pennisetum purpureum*) ad libitum and 200 g of a grain based concentrate (wheat bran, soybean meal and sorghum grain) every day. Fresh leaves (50 g) of each plant were offered on a daily basis during the 5 day adaptation period.

From days 6 to 10 of the experiment, preference was measured using a multiple Latin square design (Borman et al. 1991). animals were offered fresh leaves of each plant ad libitum in individual plastic feeders for 4 hr periods. Position of feeders was changed daily to avoid conditioned learning (association) between feeder positions and forage species. Based on preliminary observations of container capacity, at least 200 g fresh leaves were always available. Refusal was measured every hour to obtain the cumulative intake and containers replenished with measured amounts of the respective fodder material.

After the 4 hr period, tree forages were withdrawn, and individual animals received concentrate feed (200 g) and grass (ad libitum). The food was offered for 15 hr only. For the remaining 5 hr, animals were maintained without feed. Fresh water was available at all times. Experimental period lasted 4 days (Table 1). Daily feed samples were collected, dried (60 °C), milled (1 mm sieve) and kept in airtight containers for later analysis.

Preference experiment 2

In this experiment, the choice of forage was restricted to the three tanniniferous plants only (*H. albicans*, *A. gaumeri*, *L. leucocephala*). The experimental period was preceded by an adaptation period which lasted 4 days (Table 1). Management was similar to experiment 1. Feeding and sampling procedures were performed as described above.

Table 1.

Experimental designs of the experiments.

Experimental stage	Foliage offered (fresh basis)
Adaptation	50 g/d
Preference experiment 1 with 4 plants	Ad libitum
(1) Five animals with PEG	
(2) Five animals without PEG	
Adaptation	50 g/d
Preference experiment 2 with 3 plants	Ad libitum
(1) Five animals with PEG	
(2) Five animals without PEG	

Variables

Total foliage intake (TFI) and intake rate (IR). TFI was recorded as the difference between the weight of the feed offered and the weight of the foliage remaining after the 4 hr of consumption. For each animal, time spent feeding (minutes) of each foliage during hr 1 and 4 was recorded and IR calculated as the amount of feed consumed (DM) per effective minute spent eating each feed. Average IR was calculated by pooling the data from hr 1 and 4.

Foliage density and biological activity. Density and biological activity were reported by HERNANDEZ-ORDUÑO et al. (personal communication) as the same foliage was used in a contemporary experiment with hair sheep. Foliage densities of *A. gaumeri*, *H. albicans*, *L. leucocephala* were similar among them and all were denser than *B. alicastrum* (0.035, 0.041 and 0.041 and 0.019 respectively) ($P < 0.0001$). Biological activities were 1.70 ± 0.64, 3.52 ± 1.62, 3.77 ± 0.78 and 1.03 ± 0.05 units for *A. gaumeri*, *L. leucocephala*, *H. albicans*, and *B. alicastrum* respectively.

Selectivity Index (SI). The SI was calculated daily for each individual goat during the experimental periods. This gave a measure of the extent to which animals focused their selection of the diet. The SI was calculated using the following formula (DUNCAN & YOUNG 2002):

Preference experiment 1

$$SI = [(1/4 - P_i)\hat{}2 + (1/4 - P_j)\hat{}2 + (1/4 - P_k)\hat{}2 + (1/4 - P_l)\hat{}2]/(3/4)$$

Preference experiment 2

$$SI = [(1/3 - P_i)\hat{}2 + (1/3 - P_j)\hat{}2 + (1/3 - P_k)\hat{}2]/(2/3)$$

Where P_i, P_j, P_k and P_l are the proportions of the food consumed per day. An animal is qualified as completely selective when only one plant is consumed (index = 1) and it is qualified as completely unselective when the same proportions of each plant species are consumed (index = 0).

Laboratory analysis

Pooled samples were obtained per experiment and these samples were analyzed using official procedures for DM (7.007), N (2.057), and ash (7.009) according to A.O.A.C. (1980). Both NDF and ADF were not corrected for residual ash. Also NDF was determined using sodium sulfite and without alpha amylase. Lignin was also determined (VAN SOEST et al. 1991). Cellulose (CEL), hemicellulose (HEM) and cellulose+hemicellulose (CEL+HEM) were calculated by difference.

Dried samples of foliage were extracted using acetone:water (70:30 v/v). Samples were sonicated for 20 min. Then centrifuged for 10 min and supernatants were used to determine phenolic compounds: total phenols (TP) (PRICE & BUTLER 1977), total tannin (TT) (Folin-Ciocalteu + PVPP method, MAKKAR et al. 1993). Condensed tannins (CT) were determined by Butanol HCL (anthocyanidin equivalent, PORTER et al. 1986) and vanillin assay (catechin equivalent, PRICE et al. 1978).

Statistical analysis

In all experiments, preference, (measured as g DM intake), intake time (min) and IR (g DM/min) on hr 1, 4 and total were analyzed as multiple latin square designs where square = animal, columns = feeder position, rows = day of trial and treatments = each individual plant. To analyze the effect of PEG, animals were used as nominal factors, PEG treatments were used as blocks and the interaction PEG × plant was included in the model.

The SI was compared between experiments; hence data from both experiments was analyzed with a general linear model which included the effect of PEG and *B. alicastrum*, as well as their interaction in a 2 (with/without PEG) × 2 (with/without *B. alicastrum*) factorial design.

Density (g/cm^3) and biological activity (units of astringency) of the different foliages were compared with a completely randomized design.

Differences among means with $P < 0.05$ were accepted as representing statistically significant differences. When significant differences between means were found, Tukey post-hoc analyses were used.

Pearson correlation analyses were completed between chemical composition of the foliages and preference (DMI) where the probability value indicative of statistical significance was $P < 0.05$. The stepwise selection technique of the stepwise procedure (SAS 1991) was used in order to determine the best predictor for preference (DMI) for each experiment.

RESULTS

Chemical composition

Chemical composition is described in Table 2. The CP content of the plants ranged from 13.8 to 28.0%. *Leucaena leucocephala* had the highest content of CP while *H. albicans* had the highest Lignin and ADF content in both experiments. The *B. alicastrum* leaves had the highest NDF content amongst fodder materials. *H. albicans* had the highest content of TP, TT and CT and *B. alicastrum* had the lowest content.

Table 2.

Chemical composition (g/100g DM) of the plants offered to goats.

	CP	Lig	ADF	NDF	Cel	Hem	C + H	Ash	TP	TT	CT	
											Bu	Va
Experiment 1												
A. gaumeri	20.58	10.5	23.77	43.76	13.27	19.99	33.26	8.05	3.8	0.94	3.55	1.90
H. albicans	16.32	19.86	36.62	40.2	16.76	3.58	20.34	4.5	18.3	15.82	5.90	20.86
L. leucocephala	28.0	11.86	25.75	42.2	13.89	16.45	30.34	7.53	4.1	2.14	3.46	5.11
B. alicastrum	13.84	7.74	31.58	51.04	23.84	19.46	43.3	12.97	3.6	2.00	0.95	1.73
P. purpureum	6.16	10.94	49.2	78.99	38.26	29.79	68.05	5.76	–	–	–	–
Concentrate	21.73	1.42	7.7	26.58	6.28	18.88	25.16	5.18	–	–	–	–
Experiment 2												
A. gaumeri	20.17	10.43	23.84	43.7	13.41	19.86	33.27	7.69	9.0	6.08	4.08	2.65
H. albicans	15.91	20.81	38.3	44.44	17.49	6.14	23.63	4.26	8.1	2.55	5.09	21.06
L. leucocephala	25.03	11.84	26.56	41.91	14.72	15.35	30.07	6.87	4.3	2.32	3.50	5.17
P. purpureum	8.53	9.65	47.05	75.78	37.4	28.73	66.13	6.82	–	–	–	–
Concentrate	26.73	1.78	9.41	24.95	7.63	15.54	23.17	14.84	–	–	–	–

CP, crude protein; L, lignin; ADF, acid detergent fibre; NDF, neutral detergent fibre; Cel, cellulose; Hem, Hemicellusose; C + H, cellulose + hemicellulose; TP, total polyphenols; TT, total tannins; CT, condensed tannins; Bu, butanol-HCL; Va, Vainillin.

Selectivity (SI)

When all plants were offered (experiment 1), the SI of goats was 0.087 and 0.097 ± 0.011 with and without PEG respectively. The SI increased ($P < 0.001$) when *B. alicastrum* was removed (0.14 and 0.11 ± 0.0184 with and without PEG respectively) (experiment 2). There was no effect of PEG on SI ($P > 0.05$) but there was an effect of *B. alicastrum* presence on the SI (P < 0.0001).

Goat intake and preference

When the four plants were offered (experiment 1), preference was: *B. alicastrum* > *A. gaumeri* > *H. albicans* = *L. leucocephala* ($P < 0.0001$). This pattern of intake and time spent eating each fodder plant was set from the 1st hr after the fodders were offered (Table 3). After 4 hr, total intake and total intake time of each fodder had the same preference pattern (Table 4). Negative correlations were found between intake and CP ($r = -0.610$, $P < 0.000$) and Lignin ($r = -0.514$, $P < 0.001$) (Table 5). On the other hand, positive correlations were found between intake and FDN ($r = 0.755$, $P < 0.000$), Cellulose ($r = 0.709$, $P < 0.000$), Hemicellulose (r = 0.377, $P < 0.001$) and Hemicellulose + Cellulose ($r = 0.670$, $P < 0.000$). Negative correlations were found between phenolic compounds and intake: TP ($r = -0.293$, $P < 0.008$), TT ($r = -0.272$, $P < 0.015$), CT (Butanol-HCl, $r = -0.643$, $P < 0.000$, and Vanillin assay, $r = -0.378$, $P < 0.001$ respectively) and biological activity measured as radial diffusion ($r = -0.656$, $P < 0.000$) (Table 5). No significant relationship between PEG supplementation and intake was found ($P > 0.05$).

When only tanniniferous plants were offered, preference was *A. gaumeri* > *H. albicans* = *L. leucocephala* (Tables 3–4). Similarly, preference pattern set from the 1st

Table 3.

Intake, time spent eating and intake rate during the 1st and 4th hr respectively.

Experiment	Tree	I1 gDM	I4 gDM	T1 min	T4 min	IR1 gDM/min	IR4 gDM/min
1	*A. gaumeri*	107.12^{a}	8.27^{a}	10.29^{a}	1.64^{a}	14.08^{ab}	5.59^{a}
	H. albicans	70.73^{b}	3.30^{a}	5.91^{ab}	1.05^{a}	19.80^{b}	2.82^{a}
	L. leucocephala	44.34^{b}	4.93^{a}	5.05^{b}	1.48^{a}	13.26^{ab}	3.83^{a}
	B. alicastrum	202.16^{c}	5.09^{a}	28.66^{c}	3.03^{b}	8.05^{a}	2.03^{a}
	SD	7.03	1.51	1.04	0.33	1.74	1.26
2	*A. gaumeri*	170.48^{a}	9.55^{a}	27.12^{a}	3.86^{a}	7.64^{b}	3.79^{a}
	H. albicans	107.20^{ab}	7.82^{a}	9.52^{b}	0.83^{bc}	12.42^{a}	4.56^{a}
	L. leucocephala	45.96^{b}	4.95	8.75^{b}	2.36^{ac}	4.57^{b}	2.35^{a}
	SD	16.59	2.85	2.42	0.72	1.94	1.62

I1 = intake during 1st hr; I4 = intake during 4th hr; T1 = effective minutes eating during 1st hr; T4 = effective minutes eating during 4th hr; IR1 = intake rate during 1st hr; IR4 = intake rate during 4th hr. Means with different letter differ at $P < 0.05$. For each variable, means are compared only within and not between experiments.

Table 4.

Intake, total time, average intake rate, and total forage intake (FDMI: foliage + grass).

Experiment	Plant	Intake (gDM/4hr)	Total time (min)	Average IR (gDM/min)	FDMI (g/d–g/kg LW)
1	*A. gaumeri*	149.85[a]	11.93[a]	9.84[a]	820 – 48.48
	H. albicans	101.44[c]	6.95[ab]	11.315[a]	
	L. leucocephala	69.08[c]	6.52[b]	8.54[ab]	
	B. alicastrum	275.17[b]	31.69[c]	5.04[b]	
	SEM	9.28	1.13	1.08	
2	*A. gaumeri*	266.19[a]	30.98	4.51	710 – 41.83
	H. albicans	163.83[ac]	10.35[b]	8.21	
	L. leucocephala	63.17[bc]	11.12[c]	3.13	
	SEM	25.51	2.60	1.37	

Total time = time spent eating during 1st + 4th hr; Average IR = intake rate during the 1st and 4th hr. Means with different letter differ at $P < 0.05$. For each variable, means are compared only within and not between experiments.

Table 5.

Pearson correlation coefficients between chemical components and intake in cafeteria trials.

	Experiment 1		Experiment 2	
	r	*P*	*r*	*P*
Protein	−0.610	0.000	−0.351	0.018
Lignin	−0.514	0.000	−0.018	0.908
ADF	0.131	0.247	−0.048	0.756
NDF	0.775	0.000	0.433	0.003
Cel	0.709	0.000	−0.128	0.401
Hem	0.377	0.001	0.133	0.384
Cel + Hem	0.670	0.000	0.135	0.376
Total polyphenols	−0.293	0.008	0.557	0.000
Total tannins	−0.272	0.015	0.486	0.0001
Condensed tannins				
Butanol–HCL	−0.643	0.000	0.257	0.088
Vanillin	−0.378	0.001	−0.018	0.905
Biological activity (radial diffusion)	−0.656	0.000	−0.459	0.002

CP, crude protein; L, lignin; ADF, acid detergent fibre; NDF, neutral detergent fibre; Cel, cellulose; Hem, Hemicellulose.

Table 6.

Intake, (total g/d, as g/100 g DMI and g/kg LW) of the chemical components and secondary compounds from grass and browse tree foliage by goats in a cafeteria trial.

	CP	Lig	ADF	NDF	Cel	Hem	Ash	TP	TT	CT	
										Bu	Va
Experiment 1											
g/d	128.3	80.0	243.7	391.1	163.7	147.4	78.9	37.0	24.4	16.3	32.3
g/100 gDMI	15.61	9.73	29.65	47.59	19.92	17.94	9.60	4.50	2.97	1.98	3.93
g/kg LW	7.57	4.72	14.37	23.07	9.66	8.70	4.65	2.18	1.44	0.96	1.91
Experiment 2											
g/d	133.2	81.9	204.8	325.5	122.9	120.7	55.00	39.9	21.8	21.4	44.8
g/100 gDMI	18.79	11.54	28.88	45.91	17.34	17.02	7.75	5.63	3.08	3.02	6.32
g/kg LW	7.86	4.83	12.08	19.20	7.25	7.12	3.24	2.36	1.29	1.26	2.64

DMI, dry matter intake; LW, live weight; CP, crude protein; L, lignin; ADF, acid detergent fibre; NDF, neutral detergent fibre; Cel, cellulose; Hem, Hemicellulose; TP, total polyphenols; TT, total tannins; CT, condensed tannins; Bu, Butanol-HCL; Va, Vanillin.

hr was kept for total intake and intake time. Negative correlations were found between intake and CP ($r = -0.351$, $P < 0.018$) and radial diffusion ($r = -0.459$, $P < 0.002$) (Table 5). On the other hand, positive correlations were found between intake and NDF ($r = 0.433$, $P < 0.003$), TP ($r = 0.557$, $P < 0.000$) and TT ($r = 0.486$, $P < 0.001$) (Table 5). Relationships between PEG supplementation and intake were not significant ($P > 0.05$).

In experiment 1, average IR's of *A. gaumeri*, *H. albicans* and *L. leucocephala* were similar ($P > 0.05$). However, the IR of *B. alicastrum* was lower than that of *A. gaumeri* and *H. albicans* ($P < 0.05$). In experiment 2, IR was similar for the three plants (P < 0.05). Additionally, although not statistically compared, it was observed that, when the four plants were offered, foliage consumption intake rate and intake time of all the plants were higher during the 1st hr compared to the 4th hr. This was similar when *B. alicastrum* was withdrawn from the experiment (Table 3).

Although Forage Dry Matter Intake (FDMI: foliage + grass) and TFI (g/kg LW) diminished when *B. alicastrum* was removed (48.48 vs 41.83 and 35.14 vs 29.10 for FDMI and TFI respectively) (Table 4), the consumption of CT (g/kg LW) seemed to increase from 0.96 to 1.26 (Butanol-HCL) or from 1.91 to 2.64 (Vanillin) respectively (Table 6).

DISCUSSION

Chemical composition

For each tree species, their foliage had low variation in chemical composition which resulted in consistent nutritional values. As expected, *B. alicastrum* leaves had negligible levels of CT content while the remaining trees varied in its content. Values were similar to previous reports for the same species (Sandoval-Castro et al. 2005; Ayala-Burgos et al. 2006; Alonso-Díaz et al. 2008, 2009b).

PEG effect

Dosing animals with PEG did not have an effect on preference nor changed animal selectivity ($P > 0.05$), confirming the limited role of these compounds in short term preference studies where animals are able to choose their diets (Alonso-Díaz et al. 2008, 2009a; Baraza et al. 2009). Lower intakes have been observed when animal are restricted to the same forages used in this experiment when fed as a single feed. However, even in those cases tannins seemed to have a limited role (Alonso-Díaz 2009b). PEG effect would need to be evaluated with single forages or at higher doses in order to clarify the effect of tannins when animals cannot select amongst feeds.

Intake of CT increased when *B. alicastrum* was removed from the diet, even when a reduction in TDMI was observed. From an evolutionary point of view, it can be considered that goats are more adapted to foraging-browsing than sheep (Wilson et al. 1975; Ben Salem et al. 2000). This adaptation could be the result of the development of trade-offs which influence the extent of CT ingestion by the animals. Mammalian herbivores regulate their ingestion of PSM, rather than completely avoiding them. Ingestion or avoidance of PSM should be considered as behavioral strategies that are integrated with their physiological ability to detoxify and excrete them or to endure and overcome their effects (McArthur et al. 1991; Iason & Villalba 2006). This aspect is discussed below.

Foliage preference

When four plants were available (experiment 1), goats had preference towards *B. alicastrum* and preference was influenced by CP content (Table 5). Preference was also associated with the fiber fraction (lignin, ADF, NDF, cel, Hem + cel) and that association was stronger than that with polyphenolic compounds (FT, TT, CT) and their biological activity (Table 5). The result from this and previous experiments indicates the ability of ruminants to select forages based on their potential digestibility and hence energy supply (Sandoval-Castro et al. 2005; Alonso-Díaz et al. 2008, 2009a, 2009b). In the present trial, animals preferred plants with lower contents of lignin as *B. alicastrum* and *A. gaumeri*. Similar associations were found previously in cafeteria (Ben Salem et al. 2000) and non-cafeteria (Burns et al. 2001) trials. Lignin in the foliage can limit intake as it reduces potential digestibility of the cell walls (Van Soest 1994; Casler & Jung 2006). It has been hypothesized that lignin content may be detected orally as a hard material; thus, animals select softer forages which will also be more digestible materials (Sandoval-Castro et al. 2005). When *B. alicastrum* was excluded (experiment 2), goats preferred *A. gaumeri* fodder. A positive relationship was found between preference and NDF content ($r = 0.433$, $P < 0.003$) (Table 5). Therefore, this supports the hypothesis of preference being driven by the search of digestible material, rather than avoiding tannin intake.

When *B. alicastrum* was or was not available, lignin intake was similar (4.7 vs 4.8 g/kg LW) while Hem + Cel intake was reduced (18.4 vs 14.4 g/kg LW), indicating possible rumen fill constraints (Table 6). Rumen fill and transit of material through the rumen is regulated by the rate of particle size reduction and digestibility rate (Ellis et al. 1988). Recent evidence suggests that cows may select digestible NDF from the indigestible NDF which can result in a higher digestibility of fiber (Lund et al. 2007). Although this has not been demonstrated for small ruminants, they might have developed a similar strategy due to a smaller rumen size and faster outflow rate (VAN SOEST 1994). This would be consistent with the theory of optimal foraging.

Selectivity index

If goats are considered as generalist browsers, their intake of CT, and their feeding behavior (low SI) are possible reflections of their ecological adaptation. The low SI found in goats in this and other experiments (BARAZA et al. 2009) might reflect an adaptation to browse in a tannin rich environment. Most foliage found by goats in the native tropical forest of Yucatan while browsing is likely to contain CT. Thus, while searching and selecting browses, goats are less selective (lower SI) and seem to evenly spread the risk of PSM ingestion, likely with the goal of optimizing nutrient intake, rather than avoiding CT intake. In contrast, previous studies showed that sheep seem to be more selective (higher SI), focusing on the search of digestible material (Cel + Hem and CP) but also not specifically avoiding CT consumption (ALONSO-DÍAZ et al. 2009a).

As a result, when *B. alicastrum* was available, goats preferred *B. alicastrum* but the difference in intake with the remaining three foliages was not as large as was noticed with sheep (HERNANDEZ-ORDUÑO et al. personal communication). When *B. alicastrum* was not available, goats preferred *A. gaumeri*. It has been reported that, when sheep and goats have access to similar types of diet, they might show different selection patterns (WILSON et al. 1975; BEN SALEM et al. 2000). However, differences between goats and sheep adapted to browse in tannin rich environments are minimal (ALONSO-DÍAZ et al. 2008, 2009a) and, as discussed above, they can be explained based on their different foraging strategies.

Intake rate and foliage density

As previously suggested (ALONSO-DÍAZ et al. 2008) IR seems to be associated with foliage density. *B. alicastrum* leaves are bigger than the leaves of tannin rich plants offered in these experiments resulting in a lower density for *B. alicastrum* leaves. Hence, due to the size of the goat´s mouth and the size of leaves, animals have to manipulate *B. alicastrum* leaves one by one, spending more time and causing a lower IR. Thus, although *B. alicastrum* is a highly digestible fodder (SANDOVAL-CASTRO et al. 2005; ALONSO-DÍAZ et al. 2008), it is not an optimal decision to achieve total nutrient acquisition from this plant as it represents a higher harvesting cost for the animal. The selection decision made during the 1st hour of intake was kept along the 4 hr period (roughly the same preference pattern). Although, by the 4th hr no difference on DMI was observed between foliages due to a lower intake probably due to fill/satiety as IR was reduced (ORR et al. 2001).

CONCLUSION

The use of a PEG supplement suggests that tannins do not influence preference and selectivity of goats with browsing experience. Goats, faced with a variety of foliages as in the present cafeteria experiments, select foliages based on their content of potential digestible material (Hem + Cel).

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