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FEEDING BEHAVIOUR OF GOATS AND UTILISATION OF PASTURE AND RANGELANDS

A. NASTIS

Dept. of Range and Wildlife Sci. Univ. of Thessaloniki, Greece

SUMMARY

Grazing goats are the backbone of most of the world's marginal land enterprises. They are capable of utilising effectively a vast variety of plant species and vegetation types. Their level of production may be comparable to that of other ungulates in the improved pastures. However, their output in degraded and low productivity areas is far beyond the production of any other domestic ungulates. Evolutionary process seems to have provided selective pressure for goats to favour the opportunistic individuals which select diet from a broader array of plant species. This is achieved by their special feeding behaviour strategy, enabling them to select proper diet and to obtain adequate nutrients for meeting their requirements for maintenance and production.

An attempt is made (1) to explore the theoretical and empirical bases of feeding behaviour, (2) to examine behavioural constraints and (3) to discuss implications of foraging behaviour on production. The genetic origin, metabolic and morphological characteristics that allow goats to express this special behaviour for diet selection. In addition they are comparatively superior in relating and postingestive effects with chemical and physical plant characteristics as well as pasture structure and environmental conditions.

Keywords : Goats, feeding behaviour, pasture, rangelands, grazing

INTRODUCTION

The increasing world wide demands for red meat, along with the diminishing quantitative and qualitative forage resources, have led to better appreciating goats, which can thrive on marginal lands using low quality renewable resources. The interest has grown also because the goat, with its special feeding behaviour, is a potential tool for manipulating plant communities for other purposes and values. The proper use of goats' capabilities can lead to increased livestock production through differentiation in particular plant species in specific sites in the rangeland ecosystem.

This paper summarises recent research and information from various research teams which are members of the FAO networks as well as world wide information on feeding behaviour of goats and experimental results from utilisation of pastures and rangelands

DIET SELECTION AS INFLUENCED BY PALATABILITY

Palatability

Palatability does not depend only on the hedonic effect from the pleasant acceptance of a feed but also on the postingestive usefulness which animals relate to taste, smell, flavour and texture. Thus, a food is palatable only when the long-term postingestive feedback is positive. Hungry goats like grain with specific gustatory characteristics. Conversely, when they are only on concentrate diet they express a degree of preference for shrubs, even for tree bark, to compensate for missing nutrients or to vary the hedonic effect of ingestion.

Animals do not show preferences for flavours in the absence of postingestive effects. However, postingestive effect is connected with a taste. Goats fed current and old season's blackbrush (*Coleogyne ramosissima*) twigs acquired preference for old growth (Provenza 1995) because the new had higher levels of condensed tannins. When blackbrush was offered to naive goats there was a high variation between individuals in favour of new or old growth. But when they ate enough current growth (average 44g) it induced an aversion in them and finally all goats learned to avoid current growth.

Animals increase preferences for a food when nutritional needs are better met (Provenza 1995). Intraruminal infusion of energy (starch or propionate) increased consumption of novel onion or oregano flavoured straw. Preference developed for a specific flavour persists for at least 2 months but without continuation of the postingestive effect, palatability and consumption gradually decrease. Animals also increase preference for a substrate that ameliorates malaise. Lambs drink water with sodium bicarbonate when on high-wheat diet to reduce acidosis, while they otherwise prefer plain water (Phy and Provenza 1994). Thus can be concluded that palatability is a continuum and declines when needs are met and foods are eaten to satiety.

Diet selection

Compared to other domestic ungulates goats are more flexible in their feeding habits, expressing rapid seasonal shifts. The goat is characterised as a generalised feeder since it adapts its choice according to what is available, having a very large selection choice (Van Soest 1982). Grazing goats are obliged to shift foods since natural pastures are continuously changing composition and therefore quality. It has been demonstrated experimentally (Papachristou and Nastis 1993) that goats exhibited very rapid seasonal shifts between shrubs, grasses and forbs, depending on their availability and their seasonal nutritive value (Fig. 1). Selection rations (Nastis et al. 1993) of most species (Table 1) vary greatly from season to season. Under conditions of extreme nutritional stress Malechek and Narjisse (1987) have reported sheep forage lazily and do not cover wide areas, while goats search more vigorously, even for litter and for less palatable shrubs.

Table 1. Selection ratios (SR)* by goats of the dominant species in a shrubland during spring, summer and autumn (Nastis et al. 1993).

	Spring	Summer	Autumn
Woody			
P. brutia	5.74	1.11	0.67
Q. coccifera	- 4.54	0.39	2.12
C. incanus	- 0.34	- 7.63	- 3.08
Other	7.56	4.29	-
Grasses			
D. glomerata	3.97	6.26	6.67
Other	4.59	2.00	-
Forbs			
Clover and medics	5.62	8.02	-
Other	3.30	7.93	-
Litter	-	-	-7.84

* SR > 1 preferred, SR = 1 to -5 indifferent, SR < - 5 avoided

FORAGING BEHAVIOUR

Nutritional wisdom

Goats, like all animals, express a degree of nutritional wisdom since they select plants or parts of them higher in nutrients than the average in pasture (Arnold and Dudzinski 1978, Provenza and Balph 1990, Papachristou and Nastis 1993, Riggs et al. 1988) and avoid consuming harmful plants (Raupp and Tallamy 1991). They have two kinds of wisdom (Provenza and Balph 1990). The most important, concerns wisdom for survival which relates post ingestive effect with a specific feed. This was written into the brain stem many millions of years ago, securing survival of animals in a constantly changing world. The second kind of wisdom is the ability to relate post ingestive effects with senses. This second wisdom (Provenza and Balph 1990) was written into the cortex only during the last 3-4 million years. It involves interaction between the brain stem/limbic system and higher cortical centres. It has been proven experimentally that aversion cues are transferred even through the mother's milk (Thorhallsdottir et al. 1987). It is believed though most of the information is transferred to the young offsprings during weaning. This stage encompasses an array of nutritional, morphological and physiological changes (Martin 1984) during which young learn about foods from their mothers. However, there is no permanent fixed preference for a specific food. The food preference is reinstated by continuous sampling depending on its nutritional value. How wisely goats select their diet is not a well defined issue since there is little evidence that they can sense nutritional components in feeds.

Learning through trial and error

Animals express different dietary preferences when reared in different environments, as summarised by Provenza and Balph (1987). This indicates that forage selection is not genetically fixed and that learning play a major role. Goats' preference for certain species or combination of them is a result of the inherited gustatory olfactory but mainly of their past experience (Booth 1985). Individual animals always prefer familiar species that meet specific nutritional needs, while novel species are sampled only in small amounts (du Toit et al. 1991) so as to evaluate their usefulness. Animals prefer familiar foods while being reluctant to consume large quantities of novel foods. When animals eat one familiar and a novel food and malaise is induced They are able to discover the beneficial or harmful effects of a novel food within some time after the meal (Burritt and Provenza, 1991). As long as a species is not harmful it will continue to be consumed; otherwise it will be avoided. Trial and error learning process (Provenza and Balph (1987) seems to be the dominant learning mechanism. Animal species (Booth 1985) develop preferences for nutritionally beneficial species, while they develop aversions to poisonous and nutrient deficient species. Distel (1990) found that naive goats reared on alfalfa pellets consumed lower quantities of blackbrush than goats accustomed, to this species. Narjisse (1981), working with sheep, reported that naive animals consumed less blackbrush than accustomed but within five days no difference in consumption existed.

For goats which consume mixed meals over long periods of continuous foraging in a pasture it may be difficult to discover the value of each novel species (Thorhallsdottir et al. 1987). It seems though that by varying quantities of various novel species they conclude which species are most beneficial to them.
Rumination reinstates food cues and thus aids ruminants to associate food items with consequences (Zahorik and Houpt 1981) but when a novel species is mixed with others it may complicate detection of causatives even during rumination.

Habitat selection

Animals decisions where to feed, distance between foraging sites, for how long to graze, how long to search between bites; all greatly affects the rate and level of food intake as well as the nutritional content of their diet.

The factors governing habitat selection seems to be primarily vegetation type and composition parameters. In complex rangeland ecosystems animals congregate in areas of higher forage quality and quantity. Quality seems to be the main driving force (Bailey et al. 1995) being non linearly related to site selection (overmatching) while quantity within some limits is linearly related. In homogenous areas, though, animals alternate between foraging sites insisting on those with higher yield. Arnold (1987) and Bazely (1990) have reported that sheep preferred higher biomass grass patches quantitatively optimising intake. Due to different grazing habits goats prefer areas dominated by shrubs (Gordon and Illius 1989) while other ungulates concentrate more on mesotrophic graminoid sites where they can obtain the highest quality diet.

The decision making process is influenced, to a lesser extent by other factors such as topographic features, slope, aspect, environmental conditions as well as internal animal-related factors. When qualitative or quantitative differences are small easily accessible sites are always preferred to sites requiring higher expenditure for walking energy. Goats compared to other ungulates are less affected by topographical barriers. They search for food more vigorously even in rough terrain consuming forage up to 1,5 m height by practising bipedal grazing. Consecutive visits to a site reinforces memory for spatial distribution while herding modifies their free habitat choice. Despite the existing experimental information, the hierarchy of the factors that govern habitat selection is not yet fully understood. If we are to make the most efficient use of the renewable natural resources available in marginal areas it is essential to improve the understanding of the foraging strategy of goat, which is the animal making the best use of these ecosystems.

Factors allowing in modified feeding behaviour

It is not clear how animals relate taste and smell with digestive consequences feedback: nutritiousness or toxicity. If senses are a cue for forage value, it cannot be explained how ruminants die from over-ingesting toxic plants and also sometimes why they fail to ingest the minerals needed although they may exist in the pasture plants. Goats digestive efficiency compared to larger herbivores is expected to be inferior since they need to consume more food per unit of body mass for equivalent production level. This leads to higher feed intake and faster passage rates associated with lower digestibility (Van Soest 1982). However, the ability to digest lignified parts and also slowly digested components to a higher degree makes goats superior to cattle or sheep. For the readily digested components like sugars, protein and hemicellulose which are digested equally well in all animals, goats have no advantage.

Goats have the unique ability to utilise forage resources that cannot be utilised effectively by other ungulates (Meuret 1994) such as sheep or cattle (thorny plants and species containing high proportions of phenolic compounds). They exhibit a versatile feeding behaviour, advantage which comes mainly from their physical body structure (bipedal stance, mobility of upper lip and vigorous grazing), as well as their variable rumen microflora. allows them to cope in harsh environments. In the tropics they exploit even the meagre shrubby resources, selecting the more nutritive parts and converting them is a useful product. In the arctic they perform better than other domestic ungulates having considerable versatility in feeding behaviour, but also coping with cold weather. In temperate climates, where forages are relatively more nutritiously uniform and no special selection skills are needed to select high quality diet, goats may not be different in performance from other domestic ungulates. Goats have a more hospitable microflora environment for noxious phenolic compounds degradation, than other domestic animals. Furthermore it is believed that goats tolerate better phenolic compounds than other ungulates, due to their enlarged salivary gland ensuring extensive proline excretion, neutralising the negative effect.

Goats' diet almost always contains high proportions of lignified components whenever woody species exist within the pasture. (Table 2). Lopez-Trujillo and Carcia-Elizondo (1995) have reported that even in shrubland reseeded with grasses goats selected very low proportions of grasses. Similarly Papachristou and Nastis (1993, 1994) have demonstrated that even during spring when herbaceous species are very palatable, goats ingest high proportions of shrubs. However, when herbaceous species are more palatable, certain goat breeds (Fedele et al. 1993) may consume more herbage (63% vs. 28%). Goats naive to *Leucaena leucocephala* (leucaena) are incapable of utilising it while those that have developed the proper microbia populations thrive effectively on it. A similar phenomenon has been observed for goats naive to *Quercus coccifera* (kermes oak), which, within a week are fully adapted. Sheep require longer periods.

Table 2. Goats normally consume high quantities of lignified species when they exist in the pasture.

Source lignified species	% in diet (average)
Dumont et al. 1995	94
Lopez-Trujillo and Carcia-Elzoudo 1995	62
Papachristou and Nastis 1993	83
Papachristou and Nastis 1994	86
Rouissi and Majdoub 1988	87
Rigs et al. 1988	78

Ecosystem manipulation

Recently great effort have been devoted to improving rangelands for enhanced livestock production. These improvements usually last for a relatively short period of years depending on existing conditions and the management applied. Usually succession imposes its inexorable rules and any improvement benefits disappear within a few years especially when the management factors inducing deterioration, are not eleviated. Goats are very often used as tools (Davis et al. 1974) for clearance of firebreaks, parks or ski areas from woody species and occasionally for reducing the understory competition. Goats grazing in *Q. suber* forest (Quarro 1986) increased forest productivity by controlling the thick shrubby understory and thus reducing fire risk.

Feeding behaviour experimentation in the Mediterranean environment

Goats preference for shrubby species in the Mediterranean zone is coupled with the abundance of shrubby species in this zone. Average diet content in shrubby species over the growing season in varying density shrublands ranged from 50 to 97%. (Papachristou and Nastis 1993). Diet selection in comparison to forage on offer for a Mediterranean shrubland is presented in Fig. 1. However, kermes oak, the basal shrub in these pastures, was classified as indifferent (Table 1) while the legume *Vicia* sp. was classified as avoided.

Meuret 1994 has demonstrated that for dairy goats grazing in a *Quercus pubescens* - grassland choices between plant species varies greatly at the beginning of grazing time and stabilises after 60 minutes. Too little diversity does not provide enough stimulation too much inhibits intake since the animal is wasting time trying alternative plant choices. The first hour of grazing is the time most probably required to recondition their memory and thereafter they use this information effectively throughout the day. The high variation within the first 60 minutes of grazing might be attributed to the imbalance between the physiological feeling of hunger and the desire for new choices in the pasture.

Dumont et al. (1995) demonstrated that DMI decreased from 53 to 26 g/DM / kg $BW^{0.75}$ for goats when forage availability decreased while the decrease for llamas was more drastic from 76 to 7 g DM/kg $BW^{0.75}$. Grazing strategy between the two species was different. The goat was more selective while llama was a quicker eater.

CONCLUSIONS

1. Palatability of a plant depends from the hedonic effect on the palate but it is critically defined by its postingestive effect.

2. Animal detect flavours, but do not show preferences for them in the absence of a postingestive effect.
3. Animals with their inherited nutritional wisdom can relate senses with postingestive beneficial or harmful effects.
4. There is no permanent fixed preference for a food. Preference is reinstated by continuous sampling depending on its nutritional value.
5. Goats exhibit very rapid shifts between forages depending on their availability and graze vigorously even when forage is scarce.
6. Ability for food selection depends greatly on past experience. Familiar food is always preferred from novel food.
7. The trial and error process is the dominant learning mechanism.
8. In a nutritionsness of plant is detected by varying quantities of various novel species.
9. Grazing habitat selection in a pasture is determined primarily by forage quality.
10. Goats are more tolerant to noxious phenolic compounds than other domestic animals due to their extensive proline excretion which neutralises the harmful effect of phenols.
11. Goat with its unique feeding behaviour characteristics and its metabolic efficiency is the creature able to use and convert low quality forages into useful products.
12. Goat is a very useful tool for manipulating landscape characteristics and for reducing fire hazard of fire succeptible ecosystems.

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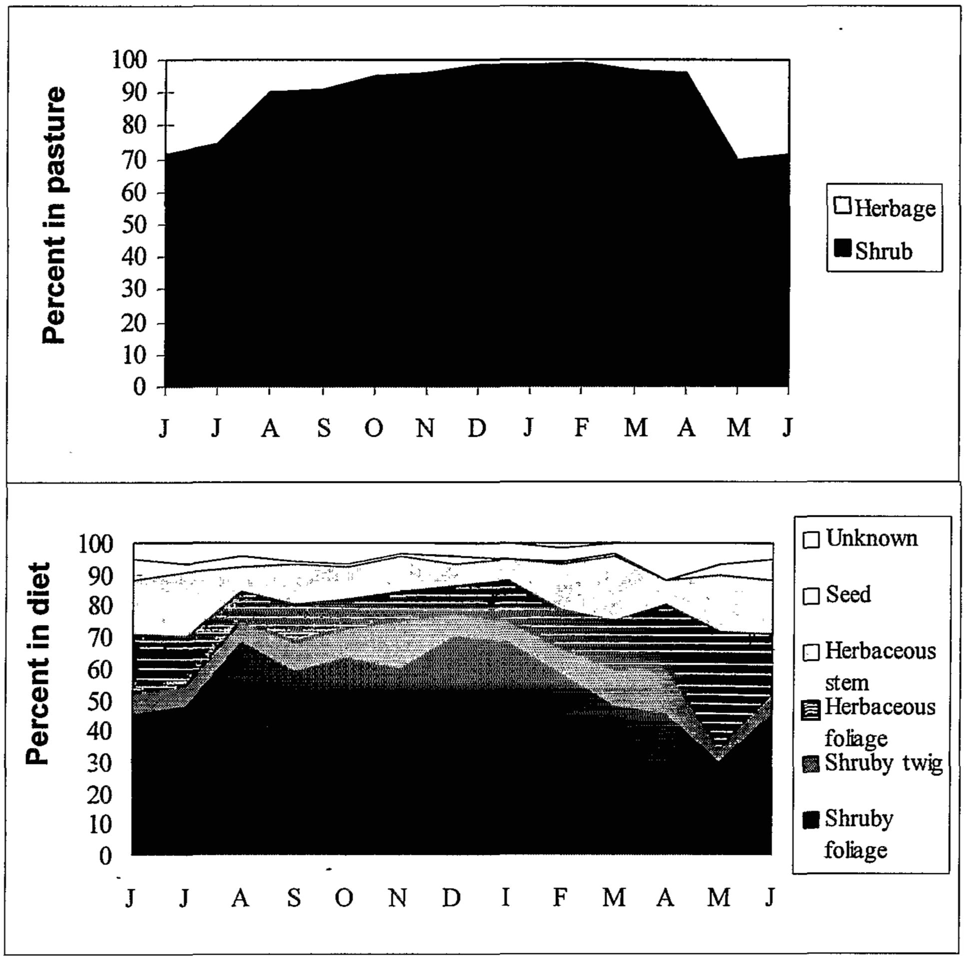

Fig. 1. Pasture composition and diet selection by goats in a Mediterranean shrubland