Diet selection of grazing goats in an oak silvopastoral system in Northern Greece using a Markov Chain Monte Carlo simulation

Manousidis T., Kyriazopoulos A.P., Papageorgiou A.C., Parissi Z.M., Abraham E.M., Koutroubas S.D., Abas Z.

in

Diet selection of grazing goats in an oak silvopastoral system in Northern Greece using a Markov Chain Monte Carlo simulation

**T. Manousidis[1]*, A.P. Kyriazopoulos[2], A.C. Papageorgiou[2], Z.M. Parissi[3],
E.M. Abraham[3], S.D. Koutroubas[1] and Z. Abas[1]**

[1]Department of Agricultural Development, Democritus University of Thrace
193 Pantazidou str., 68200 Orestiada (Greece)
[2]Department of Forestry and Management of the Environment and Natural Resources,
Democritus University of Thrace, 193 Pantazidou str., 68200 Orestiada (Greece)
[3]Department of Forestry and the Natural Environment, Aristotle University of Thessaloniki
54124 Thessaloniki (Greece)
*e-mail: T. Manousidis (thmanous@yahoo.gr)

Abstract. The diet selection of goats is affected by several factors, the most important of which are seasonality and forage availability. The purpose of this study was to investigate the seasonal changes in forage selection of goats grazing in an oak silvopastoral system in the Mediterranean region. The dietary preferences of a local breed flock were recorded using the direct observation method for two consecutive years and during three seasons (spring, summer and autumn). After a monitoring of 236 goats and their individual daily diet preferences, the basic diet profiles of the selected plant species were calculated. A multivariate analysis was performed and a clustering of profiles was obtained using Markov Chain Monte Carlo (MCMC) simulation. Woody species were involved in most of the diet profiles with *Quercus frainetto* being the dominant species selected mainly during dry periods. Herbaceous vegetation was selected predominantly during spring and whenever it was in abundance. An important part of goats' diet was acorns during autumn of oak's mast year. According to the results, goats selected mainly woody vegetation but they were able to adapt their diet in the seasonal forage availability by consuming herbaceous species.

Keywords. Diet profiles – Dietary preferences – Goats – Direct observation – Mediterranean shrubland.

Sélection alimentaire de chèvres pâturant dans un système sylvopastoral du Nord de la Grèce, en utilisant une simulation Monte-Carlo par chaînes de Markov

Résumé. La sélection alimentaire des chèvres est affectée par plusieurs facteurs, dont les plus importants sont la saisonnalité et la disponibilité du fourrage. Le but de cette étude était d'analyser les changements saisonniers dans la sélection alimentaire de chèvres pâturant dans un système sylvopastoral en région méditerranéenne. Les préférences alimentaires d'un troupeau de race locale ont été enregistrées selon la méthode de l'observation directe pendant trois saisons (printemps, été et automne) et deux années consécutives. Après enregistrement de 236 chèvres et de leurs préférences alimentaires individuelles quotidiennes, les profils d'alimentation sur la base des espèces de plantes sélectionnées ont été déterminés. Une analyse multivariée a été effectuée et un regroupement des profils a été obtenu en utilisant une simulation de type Monte-Carlo par chaînes de Markov (MCMC). Des espèces ligneuses ont été identifiées dans la plupart des profils, Quercus frainetto *étant l'espèce dominante, sélectionnée principalement pendant les périodes sèches. La végétation herbacée a été sélectionnée principalement au printemps et à chaque fois qu'elle était abondante. Les glands constituaient une partie importante de l'alimentation des chèvres pendant l'automne des années de forte fructification des chênes. Selon les résultats, les chèvres choisissaient principalement la végétation ligneuse, mais elles ont réussi à adapter leur alimentation à la disponibilité saisonnière du fourrage en consommant des espèces herbacées.*

Mots-clés. Profils d'alimentation – Préférences alimentaires – Chèvres – Observation directe – Arbustes méditerranéens.

Options Méditerranéennes, A, no. 114, 2016
Ecosystem services and socio-economic benefits of Mediterranean grasslands

79

I – Introduction

Oak woodlands cover an essential area of the total territory of Greece and 44% of the total forest cover (Papachristou *et al.*, 2005). These ecosystems are an important forage source for goats in the Mediterranean basin (Perevolotsky *et al.*, 1998). Goats are characterized as selective feeders (Ngwa *et al.*, 2000) and their diet selection is affected by several factors, the most important of which are seasonality and forage availability (Goetsch *et al.*, 2010).

The botanical composition of goats' diet is usually estimated as the average percentage of each plant or plant group selected by the animal per season or per month. This approach however, does not provide information about the daily diet profile of each individual goat, nor about the diversity of these profiles within each season or month. For this reason, a multivariate approach is needed, that considers the diet profiles as vectors in a multidimensional space. Following this approach, the diet profiles can be clustered using a variety of existing methods, thus avoiding the use of interdependent variables, as are percentages and relative frequencies.

The purpose of this study was to investigate the seasonal changes in forage selection of goats grazing in an oak silvopastoral system in the Mediterranean region, considering daily diet profiles, clustered using a Monte Carlo Markov Chain simulation.

II – Materials and methods

The study was carried out in an open oak forest in MegaloDereio, Evros region, Northeastern Greece, at 380 m a.s.l. The climate of the area is characterized as sub-Mediterranean. The average annual precipitation is 560 mm and the mean temperature is 13.7^{o}C. The vegetation composition of the area on average consists of: *Quercus frainetto (8.93*%), *Juniperus oxycedrus*(8.46%), *Cistus creticus*(15.85%),other woody species (0.72%),grasses *(35.76%),* legumes *(14.24%)* and forbs(16.04%). The area is grazed mainly by goats and to a lower extent by sheep and cattle.

The dietary preferences of a flock of 650 local breed goats were recorded using the direct observation method for two consecutive years and during three seasons (spring, summer and autumn). Grazing behavior data from 10 adult goats, randomly selected each time, were recorded for four consecutive days during each test period according to the sampling method of Altman (1974). The observations were performed sequentially from the morning to the afternoon with an interval of 10 to 20 minutes to collect forage samples for species identification. Each animal was monitored for 5 minutes and the total observation period was 50 min per day, covering a large part of the grazing time for each day.

After monitoring of 236 goats and their individual daily diet preferences (diet profiles), the basic diet profiles of the selected plant species were calculated using the behavioral data as the number of bites per plant species and bite size as the average of hand plucked samples to those consumed by the animals (El Aich *et al.*, 2007). The consumed species were grouped into 8 major categories: *Quercus frainetto, Juniperus oxycedrus*, *Cistus creticus,* Other Woody, Grasses, Legumes, Forbs and Acorns.

All diet profiles were clustered using a Markov Chain Monte Carlo (MCMC) simulation, in order to achieve an accurate and objective selection of well differentiated profile clusters, via Geneland and a specific algorithm for field data (Guillot *et al.* 2012), after 100000 iterations, sampled for each 100 values. Frequencies of the clusters for each season and year were estimated.

III – Results and discussion

According to the MCMC simulation and the modeling approach, twelve diet profiles (DP) have emerged (Table 1). *Quercus frainetto* was involved in a high percentage (more than 70%) in the

95 (DP: 1, 5, 6, 10, 11) of the 236 total diet profiles indicating that it is a basic component of the dietary pattern of goats and the most significant species in their diet. It is worth mentioning that the above diet profiles were observed mainly during the summer for both years of the experiment (Table 2), due to the low availability of the herbaceous vegetation during the dry seasons, and during the autumn of 2011, when the other palatable deciduous woody species had started to drop their leaves.

The DP_3, DP_4 and DP_9 were the profiles where herbaceous vegetation was involved in a relatively high proportion. Grasses contributed in a rate of 25.4% and 14.7% in DP_3 and DP_4 respectively (Table 1), legumes 28.3% and 36.7% in DP_3 and DP_9 respectively, forbs 26.7%, 19.0% and 50.4% in DP_3, DP_4 and DP_9 respectively. All these profiles were recorded mainly during spring (Table 2). This finding is in accordance with others authors who referred that goats select vigorously herbaceous vegetation when is available (Glasser et al., 2012).

TheMCMC simulation can identify all the significant diet profiles and the season in which they occur, even the rareones (DP_1, DP_9 and DP_11). This indicates that this method can identify both typical and opportunistic diet profiles as it uses data of each individual goat.

Table 1. The contribution (%) of each plant group species in the diet profiles (DP) of goats

Diet profile	*Quercus frainetto*	*Juniperus oxycedrus*	*Cistus creticus*	*Other woody*	Grasses	Legumes	Forbs	Acorns	N
DP_1	74.9	6.7	1.0	0.0	10.4	5.2	1.8	0.0	**1**
DP_2	51.3	0.0	0.0	47.9	0.2	0.6	0.0	0.0	**18**
DP_3	19.6	0.0	0.0	0.0	25.4	28.3	26.7	0.0	**18**
DP_4	29.9	3.4	5.7	15.5	14.7	11.8	19.0	0.0	**20**
DP_5	94.1	0.0	2.8	2.9	0.2	0.0	0.0	0.0	**29**
DP_6	98.2	1.6	0.0	0.0	0.2	0.0	0.0	0.0	**37**
DP_7	3.1	4.5	23.2	0.0	24.1	3.5	1.7	39.9	**19**
DP_8	43.3	15.7	4.0	0.0	13.6	17.9	5.5	0.0	**39**
DP_9	0.0	0.0	0.0	1.8	11.1	36.7	50.4	0.0	**1**
DP_10	72.2	5.4	7.4	14.7	0.3	0.0	0.0	0.0	**22**
DP_11	82.9	0.0	0.2	2.5	3.7	0.0	10.7	0.0	**6**
DP_12	18.6	28.2	21.0	0.0	4.0	0.0	0.0	28.2	**26**

N= the number of diet profiles.

The most frequent diet profiles during spring in both years were DP_8, DP_4 and DP_3 with a frequency in the total profiles of 0.360, 0.278 and 0.250 respectively during 2010 and 0.525, 0.175 and 0.125 during 2011.

There were differences between 2010 and 2011 as regards the summer diet profiles. During the summer of 2010 more diets profiles were recorded than in the summer of 2011 (Table 2) although all of them had as the main component *Quercus frainetto* or other woody species (Table 1). This diversification was probably observed because the flock was leaded by the shepherd to regions where there were more palatable species available. Baumont et al. (2000) referred that the grazing management decision of shepherds is an important factor that influences the dietary preferences of goats.

Acorns participated to a high rate mainly in DP_7 and DP_12 (39.9% and 28.2% respectively) (Table 1). Both profiles were observed during autumn 2010 in a high frequency of 0.475 and 0.375 respectively (Table 2). A lot of acorns were available as a feed during autumn 2010 which was a masting year. On the contrary, there were no acorns during autumn 2011 and the most frequent diet profiles were DP_5, DP_10 and DP_6 at a rate of 0.350, 0.325 and 0.200 respectively. It is worth noting that these diet profiles were typically recorded during summer.

Table 2. The frequency of participant of each diet profile (DP) in seasons for the two years

Diet profile	Spring_10	Summer_10	Autumn_10	Spring_11	Summer_11	Autumn_11
DP_1	0	0	0	0.025	0	0
DP_2	0	0.025	0	0.050	0.350	0.025
DP_3	0.250	0.025	0.075	0.125	0	0
DP_4	0.278	0.075	0	0.175	0	0
DP_5	0	0.075	0	0.025	0.275	0.350
DP_6	0	0.400	0	0	0.325	0.200
DP_7	0	0	0.475	0	0	0
DP_8	0.360	0.050	0.075	0.525	0	0
DP_9	0.028	0	0	0	0	0
DP_10	0	0.150	0	0.025	0.050	0.325
DP_11	0.028	0.100	0	0	0	0.025
DP_12	0.056	0.100	0.375	0.050	0	0.075

IV – Conclusions

MCMC simulation is a method of analysis for diet selection of grazing goats that allows to study, based upon individual dietary patterns, the frequency and seasonal distribution of diet profiles, even the identification of typical and opportunistic seasonal diets. Woody species were involved in most of the diet profiles with *Quercusfrainetto* being the dominant species selected mainly during the dry periods and secondarily during autumn of 2011.Herbaceous vegetation was selected predominantly during spring and whenever it was in abundance. An important part of goats' diet was acorns during autumn 2010 (oak's mast year). According to the results, goats selected mainly woody vegetation, but they were able to adapt their diet in the seasonal forage availability by consuming herbaceous species.

References

Altmann J., 1974. Observational study of behavior: sampling methods. In: *Behavior*, 49, p. 225-265.

Baumont R., Prache S., Meuret M. and Morand-Fehr P., 2000. How forage characteristics influence behavior and intake in small ruminants: review. In: *Livestock Production Science*, 64, p. 15-28.

El Aich A., El Assouli N., Fathi A., Morand-Fehr P. and Bourbouze A., 2007. Ingestive behavior of goats grazing in the Southern Argan (*Argania spinosa*) forest of Marocco. In: *Small Ruminant Research*, 70, p. 248-256.

Glasser T.A., Landau S.Y., Ungar E.D., Perevolotsky A., Dvash L., Muklada H., Kababya D. and Walker J.W., 2012. Foraging selectivity of three goat breeds in a Mediterranean shrubland. In: *Small Ruminant Research*, 102, p. 7-12.

Goetsch A.L., Gipson T.A., Askar A.R. and Puchala R., 2010. Invited review: Feeding behavior of goats. In: *Journal of Animal Science*, 88, p. 361-373.

Guillot G., Renaud S., Ledevin R., Michaux J. and Claude J., 2012. A unifying model for the analysis of phenotypic, genetic, and geographic data. In: *Systematic biology*, 61(6), p. 897-911.

Ngwa A.T., Pone D.K. and Mafeni J.M., 2000. Feed selection and dietary preferences of forage by small ruminants grazing natural pastures in the Sahelian zone if Cameroon. In: *Animal Feed Science and Technology*, 88, p. 253-266.

Papachristou T.G, Platis P.D. and Nastis A.S., 2005. Foraging behaviour of cattle and goats in oak forest stands of varying coppicing age in Northern Greece. In: *Small Ruminant Research*, 59, p. 181-189.

Perevolotsky A., Landau S., Kababia D. and Ungar E.D., 1998. Diet selection in dairy goats grazing woody Mediterranean rangeland. In: *Applied Animal Behaviour Science*, 57, p. 117-131.