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Intake of plants containing secondary compounds by sheep grazing rangelands in the province of Boulemane (Morocco)

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Abstract. Understanding the feeding choices of ruminants grazing pastures containing plant secondary compounds (PSC) can help designing pastoral management strategies which stimulate the consumption of rangeland vegetation, while preserving its biodiversity and regeneration potential. In this objective, a survey was carried out with 35 breeders then 11 shepherds in the province of Boulemane in eastern Morocco. The sheep farming systems investigated were based on the exploitation of natural vegetation of the steppes and hills whereby alfa and sagebrush are predominant. The aims of the study were: (1) to determine the preferences of sheep in terms of plant species ingested, (2) to identify the main factors influencing these behaviours and (3) to relate these observations to the chemical composition of the parts ingested in particular the plant secondary compounds (phenols and tannins). Despite the relatively varied species present on the rangelands, only around 8-10 species were considered by shepherds as being relevant as forage resources. The relative preferences of sheep between these species varied according to shepherds and sites. Farmers implemented seasonal management strategies, based on the relative palatability and availability of the plant species on the rangeland. Further analyses will determine the possible relation between plant composition, grazing and supplementation management, and sheep preferences.

Keywords. Rangelands – Feeding behaviour – Secondary compounds – Grazing management – Local ecological knowledge.

Ingestion de plantes contenant des composés secondaires par des brebis pâturant sur parcours dans la province de Boulemane (Maroc)

Résumé. *Comprendre les déterminants des choix alimentaires dans des pâtures riches en composés secondaires peut aider à mettre en place des modes de conduite qui stimulent l'ingestion tout en maintenant la biodiversité et la capacité de régénération des végétations. Dans cette optique, une enquête fut conduite auprès de 35 éleveurs puis de 11 bergers dans la province de Boulemane dans l'est du Maroc. Les systèmes d'élevage ovins ciblés étaient basés sur l'utilisation des parcours de steppe et de colline, à faciès d'alfa et d'armoise principalement. Les objectifs de l'étude étaient les suivants: (1) déterminer les préférences des ovins en termes d'espèces végétales ingérées, (2) identifier les principaux facteurs qui influencent ces comportements et (3) corréler ces observations à la composition chimique des parties ingérées et en particulier à la teneur en composés secondaires (polyphénols et tannins). Malgré la diversité d'espèces présentes sur les parcours, seulement 8-10 espèces étaient perçues comme ressources fourragères par les bergers. Les préférences perçues variaient selon les bergers et les parcours. Les éleveurs adaptaient leur stratégie de conduite selon la saison, en fonction de l'appétence relative et de la disponibilité des plantes sur les parcours. Des analyses complémentaires devraient permettre de comprendre les liens entre composition chimique des plantes, ingestion, complémentation et préférences des ovins.*

Mots-clés. *Parcours – Comportement alimentaire – Composes secondaires – Conduite du pâturage – Savoirs de bergers.*

I – Introduction

Rangelands are important sources of forages for the rearing of small ruminants particularly in the arid regions (Allen-Diaz *et al.,* 1996). They provide cheap forage but also support ecological services (carbon sequestration, biodiversity preservation, water quality (Havstad *et al.,* 2007). In the Mediterranean region, rangelands are often degraded, either by under-utilization causing shrub encroachment and increased fire risk (southern Europe) or by over-utilization resulting in the disappearance of perennial species and the development of low-palatable, invasive species and bare ground, with consequent erosion, soil end fertility losses (Northern Africa). In Mediterranean rangelands, many typical browse species and a number of forb species contain considerable amounts of condensed tannins or other PSCs (Jouven *et al*., 2010).

Plant secondary compounds (PSCs) are substances produced by the plants to resist herbivory and as such generally limit grazing by causing aversion in terms of astringencies and even toxicity when ingested (Jensen *et al.,* 2013). At pasture, the profile of plant species and plant parts ingested by ruminants is affected by many factors among which the presence of PSCs (Provenza and Ropp, 2001). Diet composition in PSC-rich pastures might be determined by the types and amounts of PSCs in the plant parts and the association of nutrients and toxins in the whole diet, with possible compensations due to nutrient-toxin and toxin-toxin interactions (Provenza *et al.*, 2003).

Understanding the feeding choices of ruminants grazing PSC-containing pastures can help designing pastoral management strategies which stimulate the consumption of rangeland vegetation, while preserving its biodiversity and regeneration potential. The aim of this work was to assess, based on farmer's knowledge, the consumption of PSC-containing plants by sheep grazing Mediterranean rangelands and the possible interactions with the feeding management. This paper presents the preliminary results of this study.

II – Materials and methods

The area investigated was the natural rangelands in the province of Boulemane (in the Middle Atlas of Morocco) on three sites (Boulemane, El Ksabi and Guigou). Interviews were carried out with 35 local farmers in order to describe the local farming systems and identify a few experienced shepherds which would accept to discuss about sheep feeding behaviour and management practices. Extensive interviews were carried out with 11 shepherds, following the method of Meuret (1997). They were done out on the rangeland, while the shepherd guided the flock, and included, at the end, the identification of a number of local plant species based on photographic clichés. The objective of these interviews was to collect information on the local ecological knowledge of shepherds in terms of plant species ingested, preferences, aversions, grazing patterns, seasonality and circumstantial grazing if any. In order to assess plant nutritional and anti-nutritional compounds, vegetation samples of plant parts ingested by sheep were collected on the rangelands, dried at 40°C then analysed with near infra-red spectroscopy (NIRS) for chemical composition; laboratory analyses (Landau *et al*., 2004) were performed to determine polyphenol and tannin contents (PSCs).

III – Results and discussion

1. The farming systems in the three sites surveyed

At Boulemane (average altitude of 1900 m) sheep farming dominates, and the animals are grazed on steppes and hillsides. El Ksabi (average altitude of 1100 m) is located between Boulemane city and Missour and is an area of oasis with olive orchards and cereals fields. The third local-

ity surveyed was around the town of Guigou (average altitude of 1500 m) and is characterised by woody hills. Sheep graze dry rangelands all year round in Guigou. In Boulemane, due to cold and snowy winters and in Eksabi, due to forage scarcity, flocks are moved to other areas (for ex. near Guigou) for winter grazing.

For all the sites surveyed, flock size was quite uniform at around 200 heads with *Timahdite* being the main ovine breed, chosen for its adaptation to cold during winter months. Herd composition was mainly sheep in Boulemane and Guigou whilst in El Ksabi almost half of the herd was goats due to the relatively warmer and drier conditions in the area and the presence of bushes similar to *Ziziphus lotus (L.)* Lam which is consumed mainly by goats. All the farmers complained about lack of water both for livestock drinking and biomass development. Shepherds main preoccupation was to use the resources available to maintain a sizeable flock for as long as possible without recurring to supplementation.

2. Diversity of forage species on the rangeland and sheep preferences

From the interviews of the shepherds, it was found that shepherds considered only a limited number of species (the most abundant) as being relevant for grazing. In Boulemane, the main species cited by shepherds were *Stipa* sp. (local name: halfa), *Thymus ciliatus* (azoukini), *Poa* sp. (tawarra), *Santolina rosmarinifolia* (shiha), *Eruca vesicaria* (haarein), *Rosmarinus officinalis* (azir), *Ranunculus* sp (lafoudfoulous) and *Adonis aestivalis* (shook). In El Ksabi, shepherds identified *Stipa tenasissima (*halfa*)* as the main forage species and *Perganum harmala* (harmal), *Artemisia herba-alba* (shiha) and *Thymus ciliatus* (azoukini) as the other significant forages found on the rangelands. In Guigou, *Quercus rotundifolia* (karoush), which was considered by shepherds as the main source of forage in winter. The other species considered as important by shepherds were *Poa* sp. (tawarra), *Thymelea* sp. (talzazat*), Scorzonera pygmaea* (tinegmit*), Genista quadriflora* (casdir*) and Nonaea mucronata* (agarbaz*).*

The relative preferences of sheep between these species varied according to shepherds encountered and sites: thus in Boulemane and Guigou, the most preferred species were those bearing flowers such as *Eruca vesicaria* and *Scorzonera pygmaea* whilst in El Ksabi, the biodiversity of the rangelands appeared to be poorer and so the species preferred was *Stipa* sp. However, these preferences change with the season due mainly to the availability. For example, in summer, *Perganum harmala* which is generally disregarded by sheep, is well grazed probably due to the scarcity of other species and also because when wilted it is less “smelly” which is a peculiarity of that species and could be the cause of the avoidance observed in sheep. Interestingly, some species which are quoted in the literature (Berkat *et al*., 2004) as edible forage species for the area, such as *Dactylis glomerata*, *Hieracium pseudopilosella Medicago suffruticosa* and *Globularia alypum* were not cited or noted in the rangelands surveyed. Tentative explanations may be: a) there is a rarefication of these species or more plausibly b) they are not predominant in the limited zone which was covered in the study. Strikingly, during the course of the conversations with some shepherds, species which are reported as toxic in literature (Lamnaouer and Abdennebi, 1994) such as *Astragalus* sp. and *Androcymbium gramineum* when shown on printed pictures were reported not only as harmless but even as preferred species which sheep look for. This may either indicate confusion by shepherds due to the similarity of the photos shown with other species or the ability of sheep to overcome the toxic effects.

3. Chemical composition and PSC content of the species identified

In terms of nutritive value of the plants species collected from the rangelands in the area of study, there were wide variations in the parameters measured depending on species, stage of growth and plant parts analysed. Thus, the crude protein content (%DM) for example ranged from 4.0% to 24% in *Poa* sp., from 9.7% in green *Festuca* sp. to 17.2% in wilted *Festuca* sp. or from 4.0%

in the twigs to 16% in the leaves in *Santolina rosmarinifolia.* In general, as expected, leaves showed higher crude protein and lower fibre content than twigs or stem.

In terms of PSCs, the polyphenols ranged from 0.72% in *Thymus ciliatus* leaves to more than 4.05% in *Quercus rotundifolia* leaf and twig mixture. PSC concentration varied depending on the part analysed, thus we found 3.6% of polyphenols in the seeds of *Perganum harmala* but only 1.13% in the leaves. The condensed tannins (CT) levels ranged from 0.09% in *Stipa* sp. inflorescence to 1.0% in *Quercus rotundifolia.* They were positively correlated to the level of polyphenols. In this study, the levels of PSCs may have had a very limited effect on the preferences as voiced by the shepherds. In fact, in the case of *Perganum harmala*, the seeds which contain almost 3 times more polyphenols than the leaves are preferably ingested by the sheep. Such observations may be accounted for by the relatively low levels of both polyphenols and CTs in all the species analysed. These levels are below the generally accepted threshold of 2.5% which is considered by many authors as being the level at which toxic effects occur (Frutos *et al*., 2004, Waghorn *et al.,* 2003) although there is no hard and fast rule due to complex interactions amongst the different types of PSCs and nutrients (Provenza *et al.,* 2003).

IV – Conclusion

According to the sayings of shepherds, sheep keeping on the rangelands in the study area has changed very little in the past decades. The poorer forage availability experienced in recent years in Boulemane and El Ksabi was associated with water scarcity rather than with grazing practices. Tannins though ubiquitous are not found at very high levels in the plants of the steppe and do not seem to interfere with sheep feeding behaviour. Plant tannins content apparently had no noticeable bearing on the decision making of shepherds.

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