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# Rangeland grazing to improve farm performance
## Example for an extensive meat sheep farming system

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**Abstract.** The objective of our study was to investigate with bio-technical and economic simulations, whether recognising the diversity of rangeland resources and re-organising reproductive and feeding management in consequence could improve the performance of extensive meat sheep systems. We used data from an experimental farm (INRA La Fage, Larzac plateau, southern France) to build a virtual case study. The farm comprises a flock of 330 ewes with high potential productivity (Romane breed, prolificacy > 240%), reared outdoors in a harsh environment: 280 ha of rangelands of which 18 ha have been long fertilized. We applied changes in flock management ($1^{st}$ lambing at 2 years, lambing date matching grass growth) and grazing management (function of each paddock, adapted paddock size, timing and intensity of utilisation over the year). Based on model predictions, the new system is more sustainable, with a higher net income (+40%) and a lower consumption of non renewable energy (-29%). These changes are explained mainly by a higher proportion of grazed forage (0.73 compared to 0.56 of total dry matter consumption, *i.e.* +30%), especially on rangelands (+50%), which reduces the energy and money needed to supply the flock with conserved forage and concentrate. The simulation results need to be validated with field data. A better knowledge of rangeland-based system is required to improve model calibration.

**Keywords.** Rangelands – Farm management – Simulation – Grazing – Sustainability.

***Pâturer les parcours pour améliorer les performances des élevages. Exemple pour un système ovin viande extensif***

***Résumé.*** *Notre objectif était de déterminer avec des simulations biotechniques et économiques si prendre en compte la diversité des parcours et réorganiser la conduite de la reproduction et du pâturage en conséquence pouvait améliorer les performances des systèmes d'élevage ovins viande extensifs. Nous nous sommes appuyés sur les données d'une ferme expérimentale (INRA La Fage, Plateau du Larzac) pour construire une ferme virtuelle : 330 brebis avec un potentiel de production élevé (race Romane, prolificité > 240%) conduites en plein air intégral dans un milieu difficile (280 ha de parcours dont 18 ha fertilisés de longue date). Nous avons modifié la conduite du troupeau (1ère mise-bas à 2 ans, mise-bas calée sur la pousse de l'herbe) et la conduite du pâturage (fonctions aux parcs, taille des parcs, périodes et intensités d'utilisation adaptées). Les prévisions des modèles suggèrent que le nouveau système est plus durable, avec un revenu net plus élevé (+40%) et une consommation d'énergie non renouvelable plus faible (-29%). Ces changements sont dus principalement à l'augmentation des fourrages pâturés (0,73 contre 0,56 de la consommation totale de matière sèche, i.e. +30%), en particulier sur les parcours (+50%), ce qui réduit l'énergie et l'argent nécessaires pour fournir au troupeau des fourrages conservés et des concentrés. Les résultats devront être validés avec des observations de terrain. Une meilleure connaissance des systèmes d'élevages à composante pastorale permettrait d'améliorer le calibrage des modèles.*

***Mots-clés.*** *Parcours – Conduite d'élevage – Simulation – Pâturage – Durabilité.*

## I – Introduction

Rangelands are an important forage resource for Mediterranean farming systems, providing cheap forage and a reservoir of biodiversity (Hadjigeorgiou *et al.*, 2005). Because their forage production is usually of low quality and cannot be easily controlled, rangelands have been less valued in the last few decades than cultivated or fertilized grasslands: their use has mainly been restricted to very extensive systems or to limited periods of the year where animals have low nutrient requirements. In a recent review, Jouven *et al.* (2010) suggest that if grazing management took better advantage of the diversity of rangeland vegetations, forage self-sufficiency could be improved and sensitivity to climatic hazards reduced. Among the possible changes: building a flexible grazing plan, grazing young animals on rangeland in their early life, adapting supplementation and applying high stocking densities to 'force' the animals to eat a diversity of plants. As discussed by Jouven *et al.* (2009), simulation models are powerful tools to investigate the impact of management practices on the performance of farming systems.

The objective of our work was to qualify and quantify the technical, economical and environmental consequences of a shift from "common" to "improved" management practices in terms of rangeland utilization. We focussed on meat sheep farming systems of Southern France, which usually have a high pastoral component (80-95% of the surface area used by the farm is rangeland). A modelling approach was preferred in order to obtain quickly large amounts of data at farm scale. Very few simulation models deal with small ruminant farming systems in Mediterranean areas. Thus, we used a simple conceptual model to represent the functioning of the forage system, which we forced into an existing simulation model (OSTRAL) adapted to intensive grassland-based meat sheep systems (Benoit, 1998).

## II – Material and methods

### 1. La Fage experimental farm converted into a virtual farm

In order to perform realistic simulations, we needed a well-documented system. La Fage experimental farm has been rearing productive meat ewes (Romane breed, 60 kg, prolificacy >240%) full outdoors on rangelands for more than 30 years. During all this time, the system has been monitored and records have been kept, especially on animal performance and forage production on rangeland. Based on such a great amount of data, we build a virtual farm which could fit with the inputs of our models and be representative of the local agricultural context.

Our virtual farm manages 13 ha of arable land, 18 ha of fertilized rangeland and 260 ha of poor rangeland. Its flock comprises 330 females; adult females (>2 years) are allowed to suckle two lambs, young females only one. The other lambs are fed on artificial milk. Each year, 50 female lambs are kept for replacement, 20% of the remaining lambs are sold just after weaning, the others are fattened. The average mortality rate is 4% for females and 19% for lambs.

### 2. The changes in reproduction and grazing management

In the "conventional" system, the 330 females (of which 50 lambs <1 year old) are mated with 7 rams around the 5 November, thus lambing takes place around the 1$^{st}$ of April. In the foraging system, the arable land is used to produce conserved forage. Half the surface is cut twice to harvest hay silage and high quality hay, the other half is cut once in summer to harvest hay; all fields are grazed in autumn. The fertilized rangeland and the grassland re-growths are grazed first. The utilization of poor rangelands is opportunistic, low in the good years, higher in the years where the forage production is low. When grazing poor rangelands, as soon as the amount or quality of the grass decreases, the animals have access to conserved forage or concentrate to secure their feed intake. From December to mid-April, the flock is fed outdoors mainly on conserved feed (1-2 kg DM hay and 400-900 g concentrate per ewe and per day). Female lambs kept for replacement are fed concentrate (400 g/day) in order to reach a sufficient weight at mating. Rams received hay (1 kg/day) and concentrate (400 g/day) outdoors all year round. During the fattening period, the lambs are fed conserved feed indoors.

In the "improved" system, the 50 female lambs of the year are not mated. Thus, only 6 rams are needed for the remaining 280 females. Mating is delayed to the end of November in order to align lambing with the onset of herbage growth, around mid-April. Grazing takes place almost exclusively on rangelands. Poor and fertilized rangeland paddocks are specialized for a given function (ex.: "feed the replacement lambs during the summer"), and their utilisation during the year is programmed in order to fulfil that function (ex., continued: "light grazing by replacement lambs in summer to ensure high intake, then total consumption of the rest by dry ewes in late autumn"). During winter, females are supplemented with hay and concentrate, replacement lambs (>1 year old) and rams receive only forage. Lambs are fattened on grazed grass, forage and concentrate. As a consequence of these changes, 2.8 ha are available to grow cereals.

## 3. The simulation models

### *A. A simple conceptual model for grazing and forage consumption*

The consumptions of grazed herbage and conserved feed have been calculated with a simple model build on purpose on an Excel file. A major hypothesis is that the animals will ingest the conserved feed first, since it is easier to find and ingest. Thus, the intake of grazed herbage is calculated as the difference between total dry matter (DM) intake and available conserved feed. Based on INRA feeding tables (INRA, 2007) we estimated the average DM intake at 1.5 kg for dry ewes and young females (5-19 months), 2 kg for rams and 3 kg for lactating ewes. The amount of herbage available for grazing on rangelands was calculated as follows: biomass productions measured at ground level in spring, summer and autumn in La Fage (Molénat *et al*., 2005) were multiplied by 0.6 if a complete consumption was programmed, or 0.3 in case of light grazing intensity. When no utilization was programmed in spring, 40% of spring production was available for summer (only 20% if light grazing in spring). When no utilization was programmed in summer, the corresponding production would be available in autumn, divided by 2 if the utilisation took place after November. During the winter, the biomass available for grazing was set to 0.1 t DM/ha, or 0.3 t DM/ha if the paddock was not grazed earlier in the season.

### *B. The simulation model OSTRAL*

OSTRAL is a deterministic model at "campaign" scale (12-month period) developed under the Excel software. OSTRAL assists the calibration of a coherent functioning of the flock in terms of reproduction (periods and sizes of lambing ewes batches), replacement and culling rates. OSTRAL predicts mainly technical and economical variables: (i) amount of inputs used (concentrates, fertilizers, etc.); (ii) gross products (sales of animals and subsidies) but also forage and cereal production for the flock or for sale; (iii) overheads required for the system (buildings, equipments, social contributions etc..); and (iv) key economic criteria (gross margin per ewe, net income, etc.) calculated using the methodology proposed by Benoit and Laignel (2006). By introducing variability in model inputs, it is possible to assess the sensitivity of these technical and economical results to hazards on lamb mortality, ewe fertility, prolificacy, or market prices (for concentrates, cereals, energy and lambs). In order to predict environmental impacts such as the level of consumption of nonrenewable energy and greenhouse gas emissions, OSTRAL was coupled to the software PLANETE (Bochu, 2002).

# III – Results

The "conventional" system showed a good overall performance. From the technical point of view, its productivity was close to 2 lambs per ewe (>12 months) per year, with a feed self-sufficiency of 73% and grazed herbage accounting for 56% of the total feed. The net income (EU incentives included) enabled to pay the farmer (17,600 €). The energy consumption (2.2 equivalent fuel litre per kilogram carcass) was close to the average level observed in other French meat sheep farming systems (Benoit *et al.*, 2010). Greenhouse gases (GHG) emissions, at 19.4 equivalent $CO_2$, were very low compared to the average (27.7 eq. $CO_2$). An amazing result is that the management changes aimed at increasing the importance of rangeland utilization in the "improved" system enabled to increase substantially the already good system performance. The reasons for this are explained in the following paragraphs.

## 1. Slightly lower flock performance

Delaying the age at first mating increased the number of unproductive females. As a direct consequence, the number of lambings per ewe (> 12 months old) dropped from 1.00 in the "conventional" system to 0.91 in the "improved" system. Because reproductive performance is lower for young females, the flock prolificacy increased (250% instead of 242%). As a result, the productivity per ewe (> 12 months old) slightly decreased: 1.84 lamb/ewe/year instead of 1.96.

## 2. Much more forage grazed on rangeland

Planning the utilization of poor rangelands instead of using them in an opportunistic way increased by 50% the amount of herbage grazed on them (Table 1). The consumption of replacement females (<12 months) was most affected (+90%), since they were not fed concentrate any more. Because they were supplemented later in winter, ewes also grazed more (+17%). Besides, the lambs grazed during the fattening period (instead of making a second cut) and the rams were supplemented only during the winter. As a consequence, the proportion of grazed herbage in the total feed consumed by the flock increased by 30%.

**Table 1. Feed consumption in the "conventional" and "improved" systems**

| | "Improved" system | "Conventional" system |
|---|---|---|
| Grazed herbage (t DM) | 183 | 143 |
| Grazed on grassland (t DM/ha) | 1.20 | 0.50 |
| Grazed on poor rangeland (t DM/ha) | 0.42 | 0.28 |
| fertilized rangeland | 3.50 | 3.50 |
| Rangeland / total feed: whole flock | 0.68 | 0.53 |
| ewes | 0.75 | 0.64 |
| replacement (<12 m) | 0.76 | 0.40 |
| Hay consumption (t) | 42 | 66 |
| Concentrate consumption(t): whole flock | 24 | 48 |
| ewes | 11 | 18 |
| replacement | 0 | 4 |
| lambs sold | 13 | 25 |
| Feed self-sufficiency (%) (flock needs supplied by the farm) | 93 | 73 |

## 3. Surface area available to grow cereals

In the "improved" system, the proportion of grazed herbage increased while the feed requirements of the flock were slightly lower than in the "conventional" system since less females were mated each year. As a consequence, hay consumption decreased by 36% (Table 1) and forages produced on farm (grazed or conserved) covered up to 85% of flock needs (compared to 73% in the "conventional" system). Concentrate consumption was divided by two: no more supplementation of replacement lambs (no need to stimulate growth if first mating is at 19 months), reduction of concentrate given to fatten lambs (to compensate for grass being more nutritious than hay) and no supplementation during the lactation period (since the latter coincided with grass growth). Since only 10.2 ha were required for haymaking, 2.8 ha were converted into crops, and the feed self-sufficiency of the farm became very high: 93%.

### 4. A higher and more stable net income for the farmer

The net income predicted for the "improved" system is 24,600 €, which is 40% higher than the "conventional" system. This difference can be explained by a higher gross margin (97 €/ewe instead of 81) while structural costs remain relatively stable. Expenses for flock inputs are in fact lower (45 €/ewe instead of 71) while the gross product is only slightly decreased by the fewer lambs sold (143 €/ewe instead of 152). We undertook a series of 1000 simulations simulating biological and market hazards by modifying ewe fertility, prolificacy, lamb mortality and market prices within sensible ranges. The distribution of the net income predicted for the "improved" system was significantly less dispersed than in the "conventional" system (Figure 1), which means that the first is more resistant to hazards.

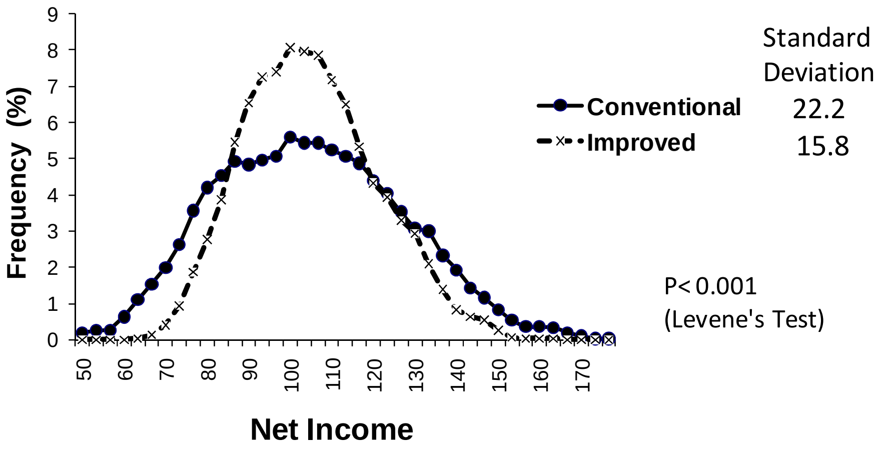


**Fig. 1. Distribution of the net income around a central value (100).**

### 5. Better environmental performance (per kg carcass)

The "improved" system also showed better environmental performance. The non-renewable energy consumption decreased by 29%, mainly due to the drastic reduction in the concentrate purchased. The greenhouse gases emissions in equivalent-$CO_2$ decreased by 10% at farm scale but only by 3% per kilogram carcass produced. Carbon dioxide emissions were 34% lower because more grazing reduced conserved feed consumption and the mechanical operations needed to harvest hay and to clear rangelands. Though, methane production per kg carcass increased by 11% because of lower ewe productivity (less lamb carcass produced) and because the animals (in particular lambs) ingested more roughage. Another environmental benefit which we did not simulate with our models is the reduced risk of shrub encroachment and subsequent biodiversity loss due to the higher utilization of poor rangelands.

## IV – Conclusions and perspectives

This simulation study suggests that giving more importance to grazing and to poor rangelands in the feeding system is a way to improve substantially the farm income, with higher feed self-sufficiency, lower sensitivity to hazards and an overall better environmental performance. The type and amount of farm work might also be different, which we did not evaluate.

Our results were obtained with an economic context close to that of 2004-2007. The advantages of the "improved" system would be even greater in a 2015-like context (results not shown). Although the perspective of high-performance extensive systems is thrilling, our simulation results still need to be validated against field data which will be collected in La Fage during the following years. Besides, a number of model parameters need to be reconsidered as soon as more knowledge will be available on rangeland-based systems. A specific simulation tool predicting the functioning of agro-pastoral farming systems is being developed, and will be very useful in the future to refine the analysis of feed and grazing management at farm scale.

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