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Trade-offs between stocking rate, forage properties and livestock performance in a Mediterranean grassland

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Abstract. Livestock management on Mediterranean rangelands is commonly determined by a combination of trial and error, accumulated experience and standards adopted by the herder. High grazing pressure creates a complex management challenge not only on the forage quality and range performance, but also on the economic consequences of the herder. The constantly changing availability and quality of the pasture that determines both the nutritional intake of the grazing animals and the role of supplementary feeding, create trade-offs between the multiple responses of the vegetation, the livestock and the cost/benefit ratio of the grazing enterprise. The aim of this study was to improve economic and environmental grazing management while quantifying the trade-offs of the system that can contribute to accomplish this goal. A long-term grazing trial was conducted on a Mediterranean species-rich hemicryptophytic grassland. Two stocking rates including moderate (M, 0.55 cows ha^{-1}) and high (H, 1.1 cows ha^{-1}) and two management protocols, continuous and split were examined. Heavier stocking reduced both standing biomass at the end of the growing season and grazing duration during the subsequent dry season but increased the weaned live-weight production per unit area, the amount of supplementary feed consumed, and the number of grazing days per unit area. Quantification of these trade-offs can guide the management of stocking rate and grazing protocol of the herd within the economic context of the grassland-livestock system.

Keywords. Beef cattle – Continuous grazing – Herbaceous biomass – Split-paddock grazing.

Compromis entre le chargement au pâturage, la valeur alimentaire des fourrages pâturés et la performance de bovins allaitants sur un parcours herbacé méditerranéen

Résumé. *La conduite du bétail sur les parcours herbacés méditerranéens est généralement déterminée par une combinaison d'empirisme, d'expérience accumulée et des standards acceptés par l'éleveur. Dans le cas d'un chargement au pâturage élevé, la conduite est complexe car, en plus des conséquences économiques, le chargement affecte la dynamique de croissance, la composition botanique et la qualité nutritionnelle de la prairie. Les changements du couvert végétal et de sa composition affectent la consommation d'herbe et la complémentation et obligent à des compromis entre les performances du bétail, celles de la prairie et le bilan économique de l'exploitation. La quantification de ces compromis peut aider à mettre en œuvre des modes de conduite plus performants. Un essai sur le long-terme a été mené dans ce but, pour caractériser les effets d'une augmentation du chargement. Un chargement élevé réduit la biomasse en fin de saison et la longueur de la saison de pâturage en période sèche mais accroit le poids de veaux sevrés par hectare, la quantité de complémentation apportée et le nombre de journées pâturées par hectare. En quantifiant ces données, on peut optimiser le chargement dans le contexte économique du système bovin allaitant.*

Mots-clés. *Bovins allaitants – Pâturage en continu – Biomasse herbacée – Pâturage en prés fractionnés.*

I – Introduction

Livestock management on Mediterranean rangelands is commonly determined by trial and error, by accumulated experience or by standards adopted by the herder. These methods are usually sufficient where the range is the only source of nutrition for the livestock during the grazing season. However, supplementary feeding has become increasingly common as a means for improving the productivity of rangeland-based livestock systems. This, and rangeland degradation, add a complicating factor to range management but also raises the possibility of increasing the stocking rate and changing the timing and duration of grazing. With higher stocking rates, the impact of grazing on the pasture vegetation and the amount of supplementary feeding increases. In addition to the economic consequences, it influences the vegetation growth dynamics, the botanical composition and nutritional quality of the pasture. The constantly changing availability and quality of the pasture that determine both the nutritional intake of the animals and the role of supplementary feeding, create trade-offs between the multiple responses of the vegetation, the livestock and the cost/benefit ratio of the grazing enterprise. Quantifying the trade-offs can contribute to more effective enterprise management.

In eastern Mediterranean grasslands that are dominated by annual species, the strongly seasonal pasture cycle is characterized by a mild, rainy winter-spring growing season and a hot and dry summer-autumn season. It is difficult to determine the optimal stocking rate over the large area required to maintain viable herds because it is influenced not only by the prevailing climatic factors but also by the vegetative composition of the range and the complex habitat characteristics (Seligman and Van Keulen, 1989). These factors are essential in the analysis of herd management decisions, especially where supplementary feeding interacts with other elements of the production system. Appropriate stocking rates under such conditions are dependent not only on the productivity of the pasture vegetation and the supplementary feeding protocol but also on the response of vegetation and livestock to grazing pressure and timing. Change in the standing biomass of a growing sward depends on the balance between the rate of pasture growth and the rate of forage consumption by the grazing herd (Noy-Meir, 1975). Deferment of heavy grazing at the beginning of the growing season to ensure undisturbed pasture establishment has been shown to prevent a fall to a low stable equilibrium (Gutman *et al.*, 1999). The aim of the current study was to quantify the trade-offs in the multiple responses of pasture growth, performance of the grazing livestock and amount of consumed supplementary feed to relatively high stocking rates in a predominantly annual Mediterranean rangeland.

II – Materials and methods

The experiment was conducted during the years 1994-2010 at the Karei Deshe experimental farm, located in the eastern Galilee, Israel (long. $35^{0}35$'E; lat. $32^{0}55$'N; altitude 60-250 m a.s.l.). The topography is hilly and the landscape is covered with basaltic rocks. The vegetation is a species-rich hemicryptophytic grassland dominated by *Hordeum bulbosum* L., *Echinops viscosus* DC., *Bituminaria bituminosa* L., and many annual species (Sternberg *et al*., 2000). The area has a Mediterranean climate, characterized by wet, mild winters and hot dry summers with an average seasonal rainfall of 560 mm, falling mostly in winter and spring. The study included different grazing scenarios based on two stocking rates and two management protocols: continuous grazing (C) of a single paddock throughout the grazing season, and a split-grazing (S) protocol with animals being moved between multiple paddocks. Grazing was deferred in all paddocks during the initial growth period. The two stocking rates were moderate (M, 0.55 cows ha^{-1}) and high (H, 1.1 cows ha^{-1}). In the split-grazing protocol the paddocks were divided into two equal sub-paddocks. Grazing began in one sub-paddock early (E) in the growing season after deferment of grazing, then the herd was moved to the second un-grazed sub-paddock later (L) in the grazing season when the amount of standing biomass was reduced to a level that subjected the herd to nutrition-

al stress. When grazed, the stocking density was high (1.1 cows·ha^{-1}) in the grazed sub-paddock of the moderate split-paddock and very high (2.2 cows·ha^{-1}) in the heavy split-paddock treatment. The two stocking rates (M, H) and two grazing management protocols (C, S) constituted four main grazing treatments (MC, HC, MS, HS). All treatments were replicated twice. The paddocks were stocked with mature, medium-frame Simford (Simmental × Hereford) crossbred cows. At weaning, the cows and calves were weighed and in September the pregnancy of each cow was determined.

The standing biomass in the paddocks was estimated. The harvested plant material was oven-dried at 65°C and weighed. The biomass was sampled every year at the beginning of grazing (January-February), at the peak of vegetation growth (April), at the end of the abundant dry pasture in early summer and the beginning of supplementary feeding (June), and at the conclusion of the grazing season (August-September). During the green season and the beginning of the dry season, the pasture was the only feed source of the experimental herds. During the later dry pasture period in summer the herds were given *ad lib* access to supplementary feed, mainly poultry litter.

III – Results and discussion

Grazing started at the end of the deferment period and ended at the beginning of autumn when the dry pasture biomass was grazed down to between 55 and 116 g m^{-2} (Fig. 1). At the moderate stocking rate, the herds were on the pasture for almost 280 days of the year and at the heavy stocking rate, just over 200 days (Table 1).

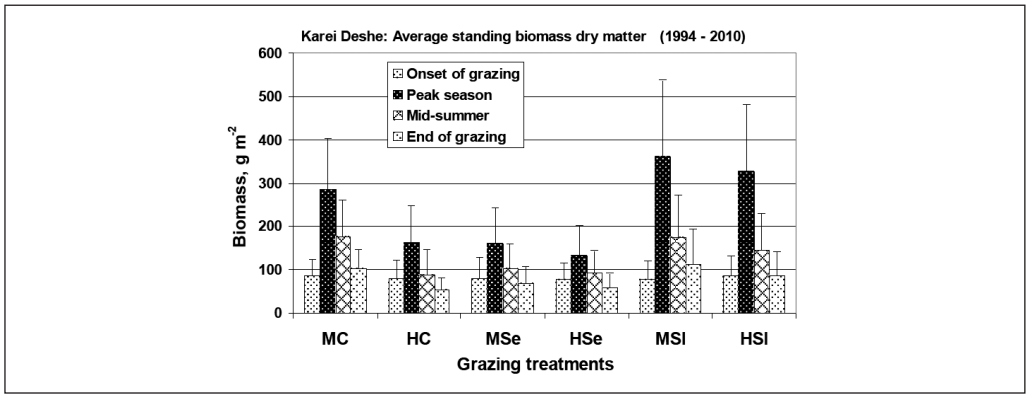

Fig. 1. Standing biomass in the moderate and heavy continuous stocking rate treatments and in the sub-paddocks of the split paddock grazing protocol (Averages and standard deviations, 1994-2010). (Main treatments: MC – moderate continuous, HC – heavy continuous; Sub-paddocks: MS_E – heavy early, HS_E – very heavy early, MS_L – heavy late, HS_L – very heavy late).

The average long-term green standing biomass when the herds entered the paddocks was between 71 and 84 g m^{-2}. Subsequently, the amount of standing biomass reflected the grazing pressure imposed on the different paddocks (Fig. 1). The standing biomass in the continuously grazed paddocks (MC and HC) was inversely proportional to the stocking rates. Adding the biomass consumption by the herd to peak biomass gave 17-year average primary production between 219 and 397 g m^{-2}. The amount of poultry litter consumed was clearly related to the stocking rate and to the availability of dry pasture biomass during the late summer. Even though the animals at the heavy stocking rate were on pasture for a shorter period, the consumption of supplementary feed per head was 64% higher (Table 1). The live-weight of the cows and their conception rates were higher in the split grazing treatments but the differences were relatively small so stock-

ing rate had an overwhelming, almost proportional effect on weaned live-weight per unit area of pasture: the weaned calf production was 87-89 and 41-46 kg ha^{-1} at the high and moderate stocking rates, respectively (Table 1).

Table 1. Pasture utilization, supplementary feed consumed, live-weight, conception rate and weaned calf production of herds in the different experimental treatments (Average ± S.D.)

Treatment	MC	MS	HC	HS
Days in treatment paddocks	279 ± 19	277 ± 18	198 ± 26	205 ± 27
Grazing days per hectare	156 ± 10	168 ± 29	223 ± 28	233 ± 60
Supplementary feed (kg day^{-1})	4.4 ± 2	4.5 ± 2	7.9 ± 2	6.7 ± 3
Cow live-weight on entry (kg)	429 ± 30	448 ± 25	421 ± 19	430 ± 28
Conception rate (%)	73 ± 13	76 ± 13	70 ± 6	78 ± 5
Weaned calf production (kg ha^{-1})	46 ± 12	41 ± 7	89 ± 17	87 ± 17

Under continuous grazing the herd could be maintained on pasture from the end of the early season deferment period until the end of the growing season at both the moderate and heavy stocking rates. The biomass was lower under heavy grazing both at the peak of the growing season and at the end of the dry season (Fig. 1). Nevertheless, the seed production that dispersed early in the dry season was evidently enough to allow the pasture to become established in the following year. The live weight of the cows at weaning and the weaning rates were higher in the split paddock protocol. The relative similarity in animal performance between treatments is related to the *ad lib* access of the herds to supplementary feed when the dry pasture was insufficient to maintain the performance of the herd in summer. A consequence of this procedure was an almost doubling of the weaned live weight production under the heavy stocking rate, albeit at a higher cost of supplementary feed.

IV – Conclusions

When pasture is the main stay of the herd and must supply feed for as long as possible during the year, both the grazing deferment period and the shorter grazing duration at the higher stocking rate exact a heavy cost in additional supplementary feed. The trade-offs between the larger herd required to increase stocking rates, the shorter grazing season and the heavier cost of supplementary feeding must be weighed against the higher animal production per unit area. Different combinations of stocking rate and grazing duration are possible with little effect on the persistence of the pasture vegetation. The practical implications of the trade-offs that were observed in this trial depend on a combination of the grazing strategy of the herd owner and economic context that includes the price of weaned live weight, the cost of supplementary feed and the fixed and variable costs related to rangeland ownership and management. However, under current prices of weaned live-weight and supplementary feed, the heavier stocking that increases the utilization of the pasture when it is at its highest nutritive value is found to be the more profitable use of the vegetation, but it is very sensitive to climate and economic hazards.

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