Range Dynamic and Sustainability of Mediterranean Grassland

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Range dynamic and sustainability of Mediterranean grassland

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Introduction

Mediterranean grasslands are a highly diverse and complex ecological resource of considerable economic and environmental importance. Herbaceous plant production that determines the carrying capacity of these grasslands for beef cattle husbandry is not only influenced by climatic factors, habitat characteristics, soil fertility and depth, but also by the stocking density and the nature of the grazing system (Gutman *et al.*, 1999). The yearly Mediterranean pasture cycle is characterized by a temperate, winter-spring growing season and a hot, dormant, summer-autumn dry season. Consequently, pasture growth dynamics result in extremely low biomass availability at the beginning of the rainy season and abundant biomass at the peak of the growing season (Henkin *et al.*, 1998). This is followed by a sharp reduction in amount and quality of the herbaceous vegetation caused by seed dispersal, desiccation, grazing and weathering during the hot and dry summer. Grazing pressure and the consequently highly variable availability and quality of the pasture vegetation determine the nutritional intake of the grazing animals as well the impacts on the growth dynamics of the pasture. High stocking densities interact with forage biomass production, consequently, the amount of standing biomass in the pasture decreases when stocking density increases above a moderate stocking rate. During maturation and seed development, heavy grazing can reduce the potential for re-growth in the following season while at the beginning of the growth season, heavy grazing can inhibit pasture growth to far below that required for adequate animal nutrition. Deferment of heavy stocking at the beginning of the growing season can prevent the fall of pasture production to a low stable equilibrium (Noy-Meir 1975; Gutman *et al*., 1999). However, with increasingly heavy stocking, deferment must be severely increased to prevent serious reduction of both the growth of the pasture and the nutrition of the grazing herd. The aim of the current study was to identify the productivity and sustainability of Mediterranean grassland under different stocking densities and timing of the grazing on a predominantly annual Mediterranean pasture. The present analysis is based on a long-term experiment (1994 - 2014).

Materials and Methods

The study was conducted at the Karei Deshe experimental farm, located in the eastern Galilee in the north-east of Israel (long. 35035'E; lat. 32055'N; altitude 60 - 250 m a.s.l.). The topography is hilly, with a cover of basaltic rocks and the soil is a fertile brown basaltic protogrumosol. The area has a Mediterranean climate, characterized by wet, mild winters and hot, dry summers. The average seasonal rainfall is 557 mm, falling mostly in winter with high variability among years and months. The vegetation is hemicryptophytic grassland, green between November and April, but dry after May when plants mature and disperse seeds.

The study took place in twelve paddocks. Treatments comprised moderate (M) (0.5 cows ha^{-1}) and high (H) (1.1 cows ha^{-1}) stocking densities and maintained under two management protocols: continuous (C) and split paddock (S) grazing. Each of the split paddocks was divided to two: an early grazing season period (E) and a late season period (L). Consequently, in the paddock and sub-paddock set-up there were six grazing treatments (MC, HC, in the continuous grazing paddocks and MS_E, MS_L and HS_E, HS_L in the split grazing paddocks). All treatments were replicated twice. The paddocks were stocked with mature, medium-frame Simford (Simmental × Hereford) crossbred cows, with about 20% blood from local eastern Mediterranean breeds.

Grazing was deferred in all paddocks during the initial growth period to allow the herbage to reach a threshold beyond which the livestock could forage a substantial part of their daily requirement. The initial grazing deferment period lasted 70±23 days after the pasture had been established. At the end of the deferment period the herds were introduced to the experimental paddocks. The green grazing season lasted an average of 76 ±17 days before the pasture dried out. During the dry summer, the herds were removed from the heavily grazed paddocks in August. In the moderately grazed paddocks, the herds remained till October - November depending on the first rain.

The standing biomass in the paddocks was estimated by placing 25x25 cm quadrats at random along permanent transects. 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 period in early summer (June), and at the conclusion of the grazing season (August-September). The significant differences in the biomass over the 20 years of the experiment were determined with a GLM model based on treatments, seasons, replicates, years and the interaction between treatment and seasons (SAS Institute, 2002). The standard deviations of the average biomass values over the years are given as an indication of the extent of the inter-annual climatic variability.

Results and Discussion

The standard deviations of standing biomass between years (Table 1) were very large mainly because of the inter-annual variation in rainfall amount and distribution. Standing biomass increased with the increase of annual rainfall (Fig. 1). Consequently, the major treatment and year effects were all significant ($p < 0.001$). The differences among treatments were greatest at the peak of the growing season. In all treatments, grazing started at the end of the deferment phase and ended in the summer, when the dry pasture biomass was grazed down to between 56 and 108 g m^{-2}**,** DM. At the moderate stocking density, the herds were able to stay on the pasture for almost 270 days of the year, while at the heavy stocking density they were able to stay only 205 days.

Table 1: Average standing biomass (±Standard deviations) in the different treatments during the grazing season at Karie-deshe experimental farm from 1994 to 2014.

	Biomass harvest[1]			
	Begin	Max	**Mid**	**End**
Treatment	**Standing biomass (mean ± S.D.)**			
MC	87 ± 34	272 ± 106	166 ± 76	101± 37
HC	81 ± 36	157 ± 71	86 ± 49	56 ± 22
MS_E	81 ± 41	159 ± 41	101 ± 58	67 ± 28
MS_L	81 ± 37	339 ± 137	169 ± 88	108 ± 73
HS_E	80 ± 34	135 ± 51	90 ± 43	60 ± 25
HS_L	87 ± 41	298 ± 135	143 ± 69	87 ± 40

[1]Begin. - Onset of grazing; Max. - Peak season; Mid, - Mid-summer; End - End of grazing season.
[2] MC and HC - moderate and high continuous grazing MS_E, MS_L and HS_E, HS_L moderate and high split early and late grazing.

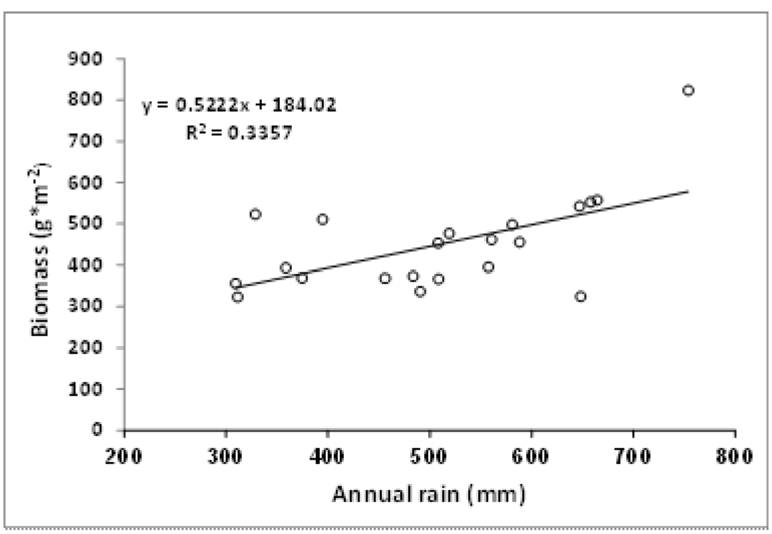

Fig. 1: The relation between standing biomass and annual rainfall at Karie-deshe experimental farm with no grazing during 1994 - 2014.

At the beginning of the grazing season, when the herds entered the paddocks, the long-term average green standing biomass was similar in all the treatments and ranged between 80 and 89 g m^{-2} DM, that was also found even in the heavily grazed split paddocks HS_E (Table 1). In the MC and HC treatments (continuously grazed paddocks), standing biomass was almost inversely proportional to the stocking density.

At the very high stocking density (HS_E, HS_L) the pasture was totally utilized before the end of the growing season. But, even under high stocking density seed production evidently was enough to enable the pasture to recover. Grazing had to be terminated before the end of the growing season, leaving enough time for undisturbed seed maturation.

Conclusion

With the introduction of the herds to the paddocks, there were no significant differences in the initial standing biomass among the treatments. This is an example of the resilience of Mediterranean grasslands that have been exposed to thousands of years of grazing. Deferment of grazing at the beginning of the growing season can enable relatively high stocking densities without damage to the pasture. Under continuous grazing during the growing season, the standing biomass of the pasture is clearly related to the increased stocking density. Under split grazing, more residual dry biomass was found at the end of the growing season.

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