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Grazing effects on a perennial legume, *Bituminaria bituminosa* (L.) Stirton, in a Mediterranean rangeland

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Summary- *Bituminaria bituminosa* (L.) Stirton is an hemicryptophyte Mediterranean legume characterized by secondary compounds in its mature leaves and by resistance to heavy grazing. Its growing season extends from before the onset of the rains to the end of the spring, attaining primary production double to that of the common herbaceous species. In winter and early spring, when more palatable species are available to the cattle, it is grazed only under heavy stocking rates. Cattle start grazing it under moderate grazing pressures only in mid-spring, when the principal grasses become less palatable. In late spring, when the herbaceous species dry up, *B. bituminosa* becomes the only species with green leaves and cattle graze the whole plant intensively. *B. bituminosa* response to grazing was studied in a long-term grazing experiment in a Mediterranean herbaceous community from 1974 to 1990. Results showed that *B. bituminosa* cover significantly increased with intensity of grazing in both deferment and continuous grazing regimes. Our observations question one of the principles of range management, that perennial herbaceous plants, and legume species in particular, are most sensitive to grazing. This principle assumes that a perennial herbaceous legume shrub under long-term, continuous heavy grazing will be completely depleted. We suggest a model explaining resistance to grazing that involve release from competition with more palatable neighboring herbaceous vegetation and prevention of grazing at the start of the green season via secondary compounds.

Key-words: *Bituminaria (Psoralea) bituminosa*, cattle grazing, and stocking rate

Résumé - *Bituminaria bituminosa* est une légumineuse hémicryptophyte méditerranéenne caractérisée par la présence de composés secondaires dans la feuille adulte et sa résistance à des charges de pâturage élevées. Sa saison de croissance précède la saison des pluies et se termine à la fin du printemps, permettant une production primaire double de celle des espèces herbacées communes. En hiver et au début du printemps des espèces plus appétentes pour les bovins sont présentes et *B. bituminosa* n'est brouée que si la charge est élevée. Sous des charges moyennes, *B. bituminosa* est brouée quand les herbacées principales deviennent moins appétentes. Lorsque ces espèces meurent à la fin du printemps, *B. bituminosa* devient la seule espèce encore verte et est alors intensivement brouée. La réponse de *B. bituminosa* au pâturage a été étudiée de 1974 à 1990 dans une communauté herbacée méditerranéenne. Les résultats indiquent que la surface occupée par cette légumineuse augmente avec la charge de pâturage et cela, sous des régimes de pâturage constant ou de mise en défense temporaire. Nos observations ne soutiennent pas le principe selon lequel les herbacées pérennes, et en particulier, les légumineuses, sont sensibles au pâturage et elles seront éliminées sous un régime de pâturage à charge élevée constante. Nous suggérons un modèle qui explique cette résistance par une compétition allégée par la plus grande palatabilité des herbacées avoisinantes et un retard du démarrage de pâturage occasionné par les composés secondaires au début de la saison verte.

Mots-clés: *Bituminaria (Psoralea) bituminosa*, bovins à l'herbe, couverture végétale, charge au pâturage

Introduction

Bituminaria bituminosa (L.) Stirton is an hemicryptophyte Mediterranean legume characterized by secondary compounds in mature leaves and by resistance to heavy grazing. Its growing season extends prior to the onset of the rains to the end of the spring, attaining primary production double that of the common herbaceous species, such as *Hordeum bulbosum* and *Avena sterilis*. In winter and early spring, when more palatable species are

available to the cattle, it is grazed only under heavy stocking rates. Cattle begin to graze it under moderate grazing pressures only in mid-spring, when the principal grasses become less palatable, due to maturation and growth of stalks. In late spring, when the herbaceous species dry up, *B. bituminosa* becomes the only species that remains green and cattle intensively graze the whole plant. Our observations question one of the principles of range management, that perennial herbaceous plants and legume species in particular are most sensitive to grazing. This principle assumes that a perennial herbaceous legume shrub under long-term, continuous heavy grazing will be completely depleted. The aim of the present study was to elucidate what are the mechanisms that allow *B. bituminosa* to survive under a heavy, long term grazing regime.

Materials and Methods

B. bituminosa response to grazing was studied at the Karei Deshe Experimental Range, situated in the Eastern Galilee of Israel, under a long-term grazing experiment in a Mediterranean herbaceous community (Gutman *et al.*, 1999). This study covered the period from 1974 to 1990. The experimental design basically consisted of six paddocks, in two blocks. In 1986 two additional paddocks were added to the study. Between 1978 and 1990 the grazing regime was yearlong; while previously to these years, grazing was seasonal (January to September/October). Treatments were light, moderate and heavy grazing pressures, combined with seasonal, deferred and yearlong grazing regimes. Species cover was monitored by the step point method, along six permanent transects that crossed the paddocks from fence to fence. The data for this study were taken from four consecutive experimental phases conducted at the same site (Table 1).

The first phase (1974-1977): Six paddocks, in two blocks, were available for the experiment. The size of the paddocks varied from 25.5 - 33 ha (Gutman *et al.*, 1999). Throughout the experimental period, three grazing treatments were replicated twice, once in each block, comparing stocking rate and seasonal grazing (continuous and rotational). The grazing treatments were seasonal continuous heavy (SCH), seasonal continuous moderate (SCM) and seasonal rotational heavy (SRH). The heavy grazing treatment was stocked at 0.9 cows/ha, while the stocking rate in the light grazing treatment was 0.6 cows/ha. In the rotational system, the paddocks were subdivided into 3 fenced subsections that were rotationally grazed over 3 - 5 week grazing periods, depending on the growth of the herbage. The second phase (1978 to 1982): This phase compared three stocking rates under yearlong continuous grazing: high (0.83 cows/ha), moderate (0.67 cows/ha) and light (0.50 cows/ha) (YCH, YCM and YCL, respectively). Yearlong grazing means that the animals were not removed from the paddocks throughout the year.

The third phase (1983 to 1985): All the paddocks were grazed continuously yearlong, four paddocks at moderate stocking rate (0.67 cow/ha) and two at light (0.50 cow/ha). The main purpose of this trial was to compare the influence of supplementary food on cattle physiology and performance.

The fourth phase (1986-90): Two new paddocks (paddocks 7 and 8) were added to the system. As in the third phase, all the cows remained in the paddocks throughout the autumn and until the beginning of the deferment period (yearlong grazing). The cows in the deferment treatments were then confined to a small sub-paddock within the treatment paddock, near the water trough and the supplementary feed station in each paddock. The stocking rates ranged from light (0.50 cows/ha) to heavy (0.83 cows/ha) with one intermediate grazing pressure (0.67 cows/ha). The treatments are described in Table 1.

Results and Discussion

During the years 1974-1978 (phase 1), when all the paddocks were under seasonal grazing and hence protected from grazing during the beginning of the growing season the cover of *B. bituminosa* was very high (about 30%) and the grazing treatment and pressures had no effect on the plant cover. From year 1978 yearlong grazing (without a protected period) was conducted. In year 1981, after 3 years of yearlong grazing, the plant cover decreased markedly, and after three more years it stabilized at 12-16 % cover, about half that under seasonal grazing. From 1978 - 1985 (phases 2 and 3) all the paddocks were under continuous yearlong grazing and the grazing pressure had no marked effect on the *B. bituminosa* cover.

Table 1. *Bituminaria bituminosa* plant cover during the different trial phases.

a. Trial composed of 6 paddocks

Year	Paddock 1 and 4		3 and 6		2 and 5	
	Plant cover (%)	Treatment	Plant cover (%)	Treatment	Plant cover (%)	Treatment
1974	22	(SCH)	32	(SRH)	20	(SCM)
1975	22	(SCH)	26	(SRH)	18	(SCM)
1978	35	(YCH)	42	(YCM)	38	(YCL)
1981	14	(YCH)	19	(YCM)	9	(YCL)
1982	4	(YCH)	9	(YCM)	5	(YCL)
1983	9	(YCM)	10	(YCM)	9	(YCL)
1984	12	(YCM)	17	(YCM)	14	(YCL)
1985	16	(YCM)	17	(YCM)	12	(YCL)

b. Trial composed of 8 paddocks

Year	Paddock 1 and 8		4 and 7		3 and 6		2 and 5	
	Plant cover (%)	Treatment	Plant cover (%)	Treatment	Plant cover (%)	Treatment	Plant cover (%)	Treatment
1986	21	(YDH)	22	(YDM)	16	(YCM)	12	(YCL)
1987	28	(YDH)	22	(YDM)	14	(YCM)	10	(YCL)
1988	27	(YDH)	25	(YDM)	15	(YCM)	10	(YCL)
1989	24	(YDH)	20	(YDM)	14	(YCM)	9	(YCL)
1990	25	(YDH)	21	(YDM)	8	(YCM)	9	(YCL)

Key: (SCH) seasonal continuous heavy, (SCM) seasonal continuous moderate, (SRH) seasonal rotational heavy, (YCH) yearlong continuous heavy, (YCM) yearlong continuous moderate, (YCL) yearlong continuous light, (YDH) yearlong deferred heavy, (YDM) yearlong deferred moderate.

From 1986 onwards the system continued to be yearlong but the vegetation under the deferment treatments (paddocks 1-8, 4-7) was protected from grazing. The *B. bituminosa* cover increased in these treatments and the difference in cover between the continuous treatment and the deferred ones was marked. As in the previous phases the stocking density has no effect on the *B. bituminosa* dominance.

B. bituminosa was resistant to grazing, even at heaviest grazing pressures. In all stocking rates its relative cover was mostly affected by year than by treatments. The grazing system (continuous, deferred, rotational) had a major effect (Fig. 1) than stocking density (Fig. 2).

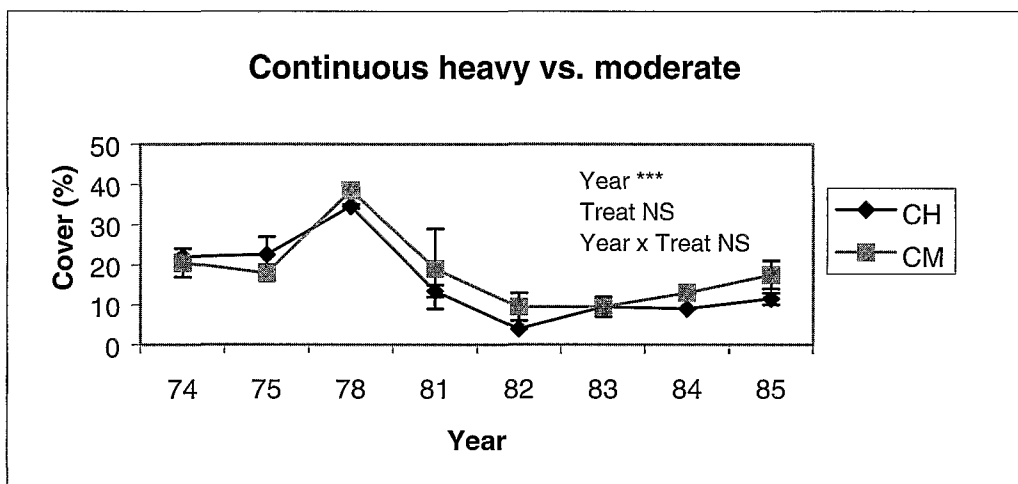


Figure 1. *B. bituminosa* cover change under continuous heavy and continuous moderate treatments.

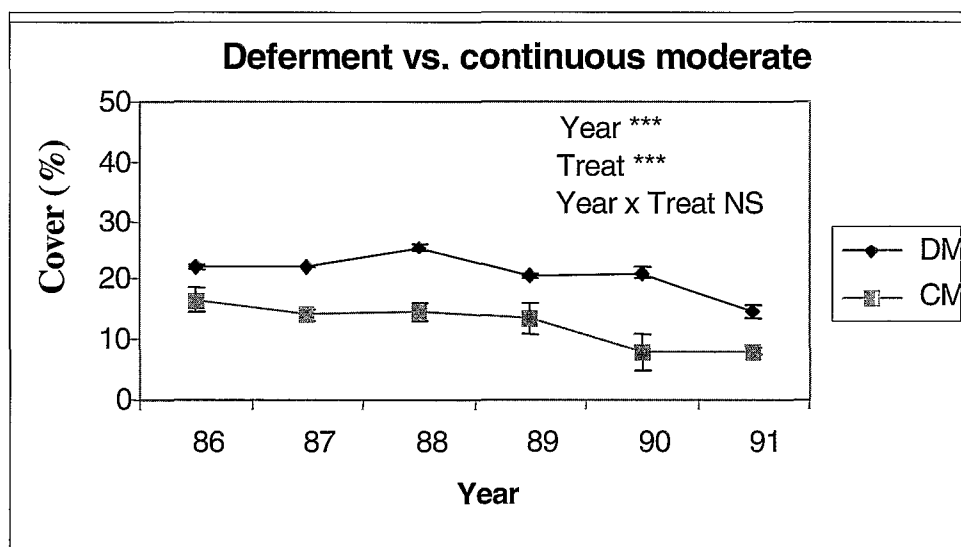


Figure 2. *B. bituminosa* cover change under deferred and continuous moderate treatment.

In paddocks under continuous grazing treatment for more than 20 years the influence of the grazing pressure (heavy vs. moderate) was less evident than the fluctuation between years (Fig. 3).

Cover of *B. bituminosa* increased more under rotational or deferred regimes than under continuous grazing. The conclusion is that this species performed better after resting from grazing during the beginning of the grazing season. The amazing result is that this species is able to grow even under extreme grazing intensities as those applied in this study.

Therefore to increase the cover of *B. bituminosa*, the paddocks have to be protected from grazing at the beginning of the growth season, or rotational grazing during the green season has to be implemented. Furthermore, we suggest that the mechanisms involved in the increase in its cover, was related to release from competition with dominant and more

palatable neighbor herbaceous vegetation and prevention from grazing at the start of the green season via the production of secondary compounds (phenolic components) in young leaves (Sternberg *et al.*, 1999; 2000).

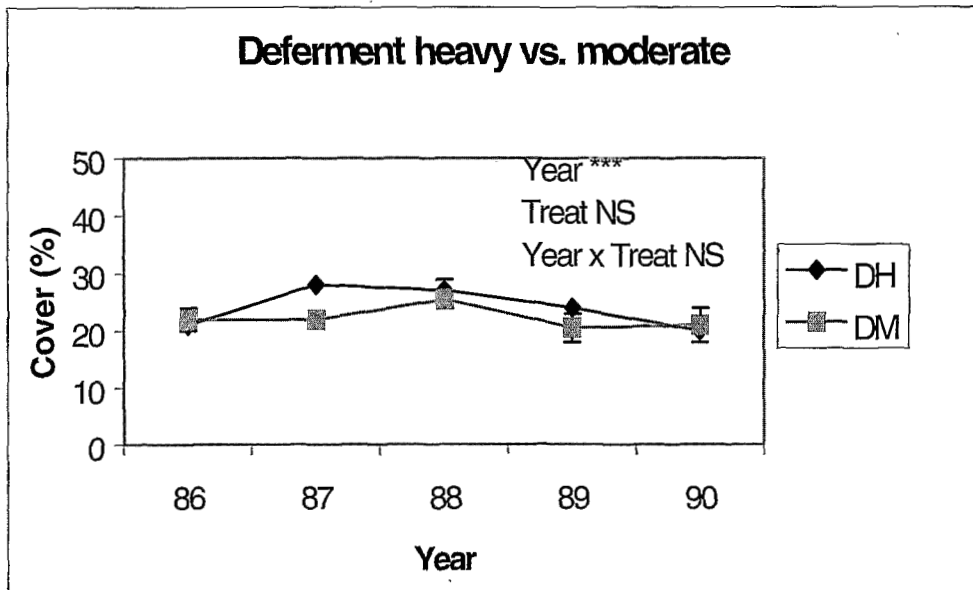


Figure 3. *B. bituminosa* cover change under deferred heavy and deferred moderate treatments.

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