Grazing Management of Mediterranean Foothill Range in the Upper Jordan River Valley

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Abstract

A grazing trial with dry beef cows was conducted on an herbaceous Mediterranean range for 10 consecutive years. It included comparisons of continuous heavy (1.2 head per ha); continuous moderate (0.7 head per ha); and rotational moderate (0.8 head per ha) grazing during the first 7 years and rotational heavy (1.3 head per ha) grazing during the last 3 years. Under continuous grazing the liveweight gain per head was higher at the moderate stocking rate, especially during the dry season. Even though the cattle received protein supplement, they began to lose weight towards the end of the summer when the pasture biomass dropped below 700-800 kg dry matter per ha. The liveweight gain per unit area was almost proportional to the grazing pressure and no diminution of the pasture production was recorded as a result of 10 consecutive years of heavy grazing. This result is attributed to the fact that less than 45% of the plant biomass was consumed during the growing season and that the amount of dead standing vegetation had little effect on the growth during the following season. The cattle in the rotationally grazed paddocks gained slightly less weight per head than those in the continuously grazed paddocks. However, on an area basis this difference was not significant. At the end of the grazing season there was more litter in the rotationally grazed paddocks than in the continuously grazed ones. Continuous and/or heavy grazing decreased the relative cover of the grasses. These were replaced by forbs (annual dicotyledons). Under equal grazing pressures the relative cover of grasses was higher in rotational than in continuous grazing. The grazing treatments had no influence on the occurrence of annual legumes, or on *Psoralea bituminosa* (a common perennial legume) and *Echinops viscosus* (a widespread perennial thistle).

> Now Abram was very rich in cattle . . .and Lot . . .also had flocks and herds and tents, so that the land could not support both of them dwelling together, and there was strife between the herdsmen of Abram's cattle and the herdsmen of Lot's cattle.—
> Genesis 13:2-7

The state of Israel is unique in that four major ecological regions are represented in a relatively small area (Zohary 1973). As a result, there is great botanical diversity in the rangeland, with many species that have become common pasture plants in other parts of the world. For the range specialist the country is also of interest because of the fact that three types of society use the rangelands with entirely different methods of management: a modern agricultural society, with range allocated to individual herds; nomadic herding, which has not changed much since the days of Abram and Lot; and, in between these two, the traditional village society of the Fallahs where range is grazed as common land.

The range types include the open oak park forest (Naveh 1967, 1970); the shrubby maqui range of the Mediterranean zone; the Mediterranean steppes; the 150–300 mm belt which constitutes the border between the desert and the sown (Tadmor et al. 1974); and the shrubby desert range (Seligman et al. 1962). The Mediterranean steppes, which are the subject of this paper, are located in the north east of the country and extend across the Upper Jordan River Valley onto the Golan plateau. These are rocky ranges in which small patches of soil have been cultivated in the past, mostly for wheat and barely crops. Agriculture with modern machinery is not feasible, except after costly land reclamation. In the last few centuries the local population grazed the range intensively with camels, horses, donkeys, cattle, goats, and sheep. All this, together with tree cutting and selective gathering of plant species for food and fuel, strongly influenced the vegetation (Sonnen 1952). The area has been inhabited since the Bronze Age. To this day early dolmens, terraces, and ruins of ancient habitations testify to the ancient history of the area. The area was noted in the Bible for the good wheat produced there (Vilnay 1953). During the period of the Ottoman Empire, the region was inhabited by Bedouin, who also extracted passage tolls from the people who travelled the main road from Galilee to Damascus.

At the end of the War of Independence in 1948, very few livestock remained, most having been removed to neighbouring countries. Slowly the range came into use again—first for sheep and cattle of dairy herds, and later mainly for beef cattle. New methods of range management were introduced, mainly with the help of the U.S. Operations Mission (USOM) to Israel, which was active from the early 1950's. It soon became apparent that more information on the carrying capacity of the range and its response to grazing was urgently needed. In 1960, the Karei Deshe experimental range was established 10 km north of Lake Kinneret, close to the Jordan River. The first trials were planned with Mr. Larry Short of the USOM. The objective of these trials was to determine the response of animals and pasture vegetation to grazing pressure and to rotational grazing in the context of the rocky, herbaceous, foothill range, typical of large areas in Israel and other parts of the Mediterranean region.

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The Experimental Site

Climate

Karei Deshe is in a winter rainfall area, with all precipitation falling between October and April and 50% in December-January. Rainfall and growing seasons are thus designated by two calendar years; *e.g.* 1966/67 refers to the year from October 1966 to September 1977. The extreme rainfall fluctuations during the trial years were 394 mm in 1972/73 and 911 mm in 1968/69. Rainfall distribution within a season greatly influences vegetation growth. Mean values are given in Table 1.

Table 1. Mean monthly precipitation for Karei Deshe, 1960–1970.

Month	Precipitation (mm)	*SD* (mm)	*CV* (%)
October	16	18	114
November	17	16	90
December	134	91	68
January	171	77	45
February	96	66	69
March	81	47	58
April	21	15	71
May	5	6	120

The coldest month is January, with mean minimum and maximum temperatures 7° and 14°C, respectively; only very seldom does the absolute minimum descend below 0°C. The hottest month is August, with mean minimum and maximum temperatures of 19° and 32°C, respectively.

Soils and topography

The soil is a basaltic protogrumosol (Dan and Raz 1970). Field capacity is about 33% (gravimetric) and wilting point is about 23%. Bulk density is 1.35. The outstanding features of the landscape are the hilly topography overlain with basaltic rocks which cover about 30% of the surface. Most of the area is inaccessible to vehicles. The slopes are gentle and the cattle can graze most of the range. There is very little erosion from the basaltic protogrumosol (Morin et al. 1976).

Vegetation

The vegetation is classified as Mediterranean transitional batha (Zohary 1973), composed principally of hemicryptophytes (*Psoralea bituminosa, Echinops viscosus, Hordeum bulbosum*). These species form 40–60% of the cover. The other botanical components include over 250 species, mostly therophytes, among which the following are prominent: Annual grasses: *Avena sterilis, Hordeum ithaburensis, Bromus* spp.; Perennial grasses (traces): *Phalaris tuberosa, Dactylis glomerata;* Legumes: *Medicago polymorpha, Medicago rotata, Trifolium subterraneum, Trifolium pilulare;* Forbs: *Scabiosa prolifera, Scolymus maculatus, Carthamus glauca, Hirschfeldia incana, Anthemis* spp., *Linum strictum*.

Seasonal development of this vegetation depends almost wholly on the rains. Only *Psoralea bituminosa* and *Echinops viscosus* begin to grow in October, before the rainy season starts. After the onset of the first effective rains, usually between mid-October and late November, the annuals germinate and the perennials emerge. The growing period extends until the end of April (or, rarely, the beginning of May), when most of the herbaceus vegetation dries up. *Psoralea bituminosa* stays green till the end of May. During the summer the only green species are *Cynodon dactylon* and *Prosopis farcata*. The latter is a thorny dwarf shrub occasionally eaten by the cattle. Some of the similarities and differences between this type of vegetation and the grasslands of California have been discussed by Naveh (1967).

Experimental Animals and Herd Management

The Cattle Herd

In each year, 150 to 200 head of cattle made up the experimental herd, which was composed of dry cows that were served during the green season (from December to May). The composition of the experimental herd followed the changes in breed composition of the beef cattle of Israel. At the beginning of the trial most of the cows were Baladi (local), Turkish, and Yugoslavian land races. The bulls were Brahman and Hereford initially, and later Simmental and Charolais. All the off-spring of the Charolais breed were sent to the feed lots, because cows with Charolais blood perform poorly on the rough, rocky range. The average liveweight of the cows at the beginning of the grazing season (January) was 260-280 kg. In 1970 the trial was conducted with heifers that weighed about 200 kg at the beginning of the grazing season.

The Grazing Season

After the first heavy rains, the residual dry vegetation decomposes quickly. The newly germinated vegetation is generally insufficient to maintain the cattle until 40 to 60 days after emergence or regrowth of perennial species. This period (from November to January) is a difficult transitional season, when supplementary feeding is generally practiced. Grazing started with range readiness in the experimental paddocks when the herbaceous vegetation was about 10 cm tall, usually between January 15 and 25. The grazing season lasted approximately 200 days and ended when the cattle in the heavily grazed paddocks began to lose weight at two consecutive weighings. The protein content of the vegetation from June to December is low, less than 4%. Protein supplements are necessary and poultry litter has commonly been used for this purpose in recent years. From 1964 to 1969 the protein supplement was 0.8 kg oil cake (cotton seed or soya) mixed with 0.2 Kg salt per head per day. In 1970 no supplement was given and from 1971 to 1973 chicken litter was supplied *ad lib*. The cattle usually consumed from 1.8 to 3.3 kg per head per day.

Treatments and Experimental Layout

The trial was conducted during 14 consecutive years (1960-1973) and can be divided into phases with the following grazing treatments:

Paddock number	Establishment and calibration phase 1960-1963 (4 years)	Grazing treatment period Phase 1964-1970 (7 years)	Phase II 1971-1973 (3 years)
1 & 4	Continuous moderate grazing in all the paddocks	Rotational moderate	Rotational heavy
2 & 5		Continuous moderate	Continuous moderate
3 & 6		Continuous heavy	Continuous heavy

In the center of the farm, six experimental paddocks were fenced and divided into two blocks of three. The paddocks varied in size from 25.5 ha to 33.8 ha and were planned so as to have a similar mix of habitat types (Fig. 1). This was done to ensure the similarity of the carrying capacities of the range in the individual paddocks. During the calibration phase, which lasted 4 years, the grazing pressure was planned to be uniform in all six paddocks. This period was regarded as necessary to disclose differences in the productivity of the pasture between the paddocks, which could complicate the analysis of the results. This was one of the methodological conclusions that could be drawn from other, similar, trials (Wagnon et al. 1959).

During the first treatment phase (1967-1970) three grazing treatments were compared: rotational moderate, continuous moderate and continuous heavy. No range improvement methods were applied besides the management of the range inherent in the grazing treatments. The stocking density was 1.2 head$\cdot$ha^{-1} for the heavy continuous and 0.8 head$\cdot$ha^{-1} for the moderate treatments (continuous and

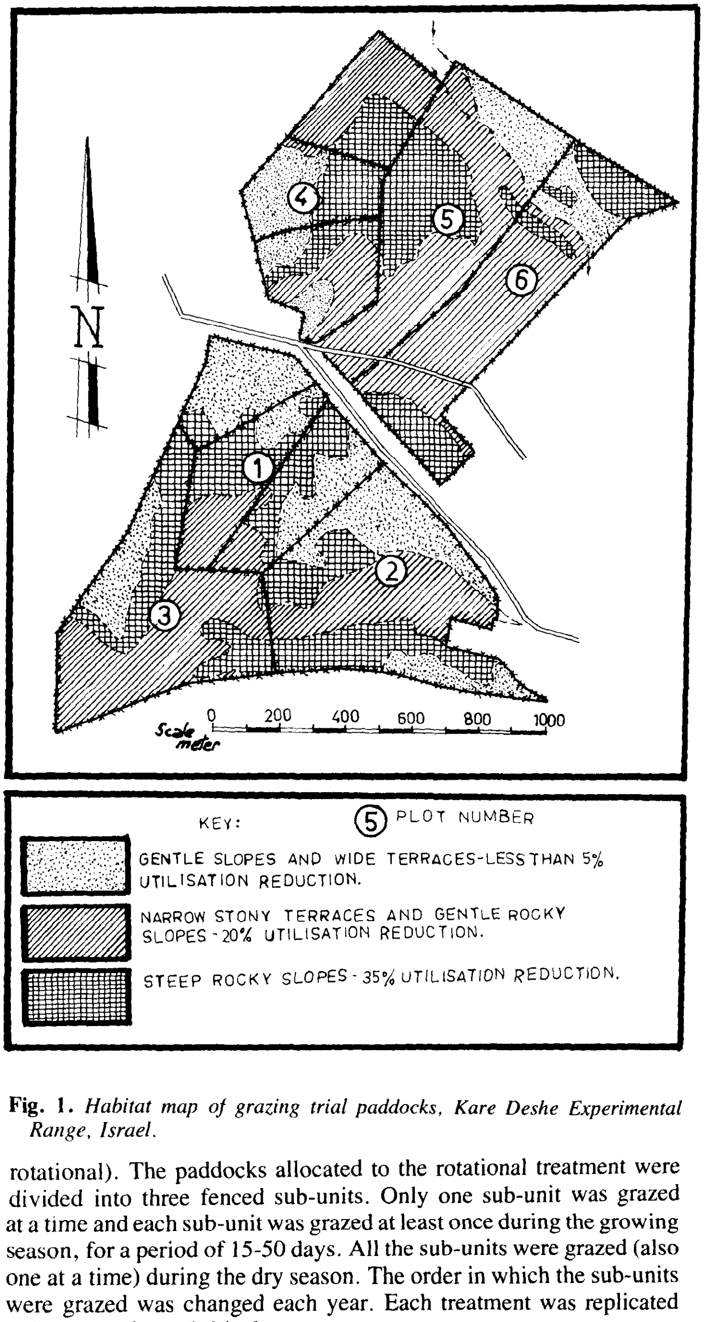

Fig. 1. *Habitat map of grazing trial paddocks, Kare Deshe Experimental Range, Israel.*

rotational). The paddocks allocated to the rotational treatment were divided into three fenced sub-units. Only one sub-unit was grazed at a time and each sub-unit was grazed at least once during the growing season, for a period of 15-50 days. All the sub-units were grazed (also one at a time) during the dry season. The order in which the sub-units were grazed was changed each year. Each treatment was replicated twice, once in each block.

During the second treatment phase (1971-1973), the grazing pressure in the rotational treatment was increased from moderate (0.8 head·ha^{-1}) to heavy (1.3 head·ha^{-1}). The other treatments were continued without change.

Methods

Climate

Rainfall was measured daily with a standard rain gauge; temperature was recorded by a clockwork thermohygrograph; potential evaporation was measured with a Class A pan.

Vegetation

At the beginning of each grazing season, the vegetation cover and botanical composition of each paddock were recorded. The observations were conducted along permanent transects, with a total length of 1,500 m in each plot. At 10-m intervals an iron quadrat, 0.25 × 0.25 m, was placed. The samples were taken only from herbaceous vegetation (annuals and *Hordeum bulbosum*). In the event of the quadrat falling on boulders or on concentrations of *Psorolea bituminosa* or *Echniops viscosus,* the quadrat was moved 1 m forward. For each quadrat, the observations included vegetation cover in relation to bare soil, and relative cover of grasses, legumes, and forbs. The plant biomass of each quadrat was determined by a double sampling method. A visual estimate was calibrated by harvesting, drying, and weighing a subsample of 10–20% of the quadrats (Campbell and Arnold 1973; Pechanec and Pickford 1973; Tadmor et al. 1975). A survey of the amount and cover of litter left in each paddock was conducted at the end of the grazing season. This survey was also carried out along the permanent transects and based on double sampling. Detailed botanical composition was determined by the step-point method (Evans and Love 1957) in 1969 and 1974.

Cattle

The dry-cows were taken from a commercial herd grazing the area adjacent to the trial paddocks. Each year about 120 head were divided into six herds between 16-24 each, depending on the treatment grazing pressure and size of paddock. The mean herd-weight and weight distribution were kept as uniform as possible. Number of animals in each paddock sometimes changed between grazing periods because of cattle jumping fences or removal due to illness or death.

All the animals were weighed at the beginning of *i-th* grazing periods , which were one-month during the green season, and 15-20 days long during the dry season. Before each weighing, the animals were held in the corrals overnight (12 to 16 hours), without food or water (Baker and Guilbert 1942). The number of days the herd spent in each paddock (d_i) was recorded for each grazing period.

Daily metabolisable energy requirements for each *j-th* cow (ED_{ij}) for each grazing period were calculated from A.R.C. tables based on body weight and on changes in the body weight during the grazing period (A.R.C. 1965; Levy and Holzer 1971). The total ME consumed per hectare (*EH*) in each paddock was calculated as follows:

$$EH = \frac{1}{a} \cdot \sum_{i=1}^{P} \left[d_i \cdot \sum_{j=1}^{n} ED_{ij} \right]$$

where,

p = number of grazing periods per season
n = number of cows in paddock
a = area of paddock in hectares
d_i = number of days in *i-th* grazing period.

EH is probably a low estimate of ME consumed as A.R.C. *ED* tables are based on hand-fed and not on grazing animals.

Calibration of Trial Paddocks

During 4 years, the treatment in all six paddocks was supposed to be continuous moderate grazing, but because of initial technical difficulties, the grazing was truly continuous over the whole grazing season only during the latter 2 years. The total apparent productivity of the pasture was calculated as the sum of the cattle intake (calculated as above) and the ME value of the ungrazed biomass at the end of the grazing season. The relative pasture productivity of each paddock (*RPP*) was calculated as a percentage of productivity of the best paddock. The analysis of the calibration period data gave the following results (Seligman and Gutman 1977).

Block A		Block B	
	RPP		*RPP*
Paddock	1=100	Paddock	4=90
Paddock	2= 96	Paddock	5=90
Paddock	3= 94	Paddock	6=90

The results show that there was little measured difference in productivity between the paddocks within Block A, and none in Block B. The differences between the blocks appear to be due more to differences in the management of the individual trial paddocks rather than to differences in the inherent productivity of the blocks. This interaction between management and productivity makes it difficult to

Table 2. Animal performance and pature production during the two phases of the trial.

Year	Precip. mm		Liveweight gain kg. head⁻¹			Liveweight gain kg.ha⁻¹			Pasture product[4] 10^3.MCal ha⁻¹			Residual litter tonne.ha⁻¹ (D.M.)		
Phase 1[1]			CH	CM	RM	CH	CM	RM	CH	CM	RM	CH	CM	RM
1964	672	(g)[2]	81	81	76	73	45	50	3.75	2.32	2.45	0.65	0.96	1.60
1965	786	(p)	77	93	91	72	52	59	3.14	2.31	2.33	0.70	1.00	1.24
1966	488	(g)	83	88	82	80	61	55	3.51	1.89	2.41	0.78	1.24	1.32
1967	684	(p)	70	85	76	85	62	54	2.68	(1.76)	(1.59)	0.67	5	5
1968	568	(g)	69	80	80	82	61	63	3.73	2.35	2.36	0.79	1.17	1.41
1969	911	(p)	84	108	100	109	85	77	3.51	2.36	2.22	0.49	1.19	1.51
1970	602	(g)	50	67	61	77	55	48	2.82	1.61	1.51	0.72	1.33	1.60
Average Phase 1	673		74	86	81	83	60	58	3.30	2.09	2.12	0.69	1.15	1.45
Signif. (6)			a	a	a	a	ab	b	a	b	b	b	a	a
Phase 2[3]			CH	CM	RH	CH	CM	RH	CH	CM	RH	CH	CM	RH
1971	657	(g)	84	79	80	107	59	96	3.26	1.87	2.95	0.66	1.28	1.00
1972	450	(p)	80	87	73	102	68	101	3.48	2.17	3.53	0.65	1.22	0.98
1973	394	(g)	60	79	61	72	65	78	2.82	2.00	2.94	0.61	1.27	0.99
Average Phase 2	500		75	82	71	94	64	92	3.19	2.02	3.14	0.64	1.26	0.99
Signif.[6]			ab	a	b	a	b	a	a	b	a	c	a	b

[1] Phase 1 treatments: CH-continuous heavy; CM—continuous moderate; RM-rotational moderate.
[2] Letters in brackets denote rainfall distribution; g-good; p-poor.
[3] Phase 2 treatments; as above except RH-rotational heavy.
[4] Pasture productivity as utilized metabolizable energy.
[5] Dry pasture burnt as a result of Syrian shelling in 1967 war. Pasture productivity of CM and RM up to June only.
[6] Significance $p=0.05$ by the Duncan multiple range test; analysis as split plot with treatment as mainplots and years as subplots. Significance much improved with factorial analysis, treatment × years, which is only partially valid as herds were changed each year but paddocks were not.

determine an absolute value for potential productivity. The average relative productivity of the two paddocks assigned to each treatment (1-4, 2-5, and 3-6) was 95, 93 and 92, respectively. For practical purposes it was decided to consider the pasture in all the treatments as uniform on a total paddock basis.

Results

Animal performance and pasture production during the trial years are shown in Tables 2 and 3.

Cattle Responses to Stocking Density

The influence of stocking density can be analysed by comparing the continuous moderate and the continuous heavy grazing treatments.

Liveweight Gain per Head. Phase I (1964-1970)

The liveweight gain per head was higher in the pastures under moderate stocking density. The difference was not large during the green season (Table 3): 0.69 kg.head⁻¹.day⁻¹ in the heavy stocking treatment compared with 0.76 kg.head⁻¹.day⁻¹ in the moderate treatment. During the dry season the difference was greater, because the daily average increase per head in the moderate stocking density was 0.04 kg, whereas in the heavy intensity treatment the animals lost weight, especially during the last month of the grazing season. The cattle began to lose weight when the amount of pasture biomass dropped below 700 kg dry matter.ha⁻¹. In spite of these low pasture biomass values, the body condition of the cattle in the heavily grazed plots was satisfactory. There were no clear differences between treatments in the percentage of cows that came into calf.

Phase II (1971-1973):

The same treatments were compared and the results were similar to those of Phase I. Two of the three years in Phase II were "drought" years (1972 with 450 mm poorly distributed and 1973 with 394 mm). In the heavy stocking treatment, the liveweight gain per head was the same in both phases (Table 2). On the other hand, in the moderate treatment the liveweight gain per head (which was higher than in the heavy stocking treatment) was lower in Phase II—apparently due to the shorter green seasons in the drought years of Phase II. In the heavily

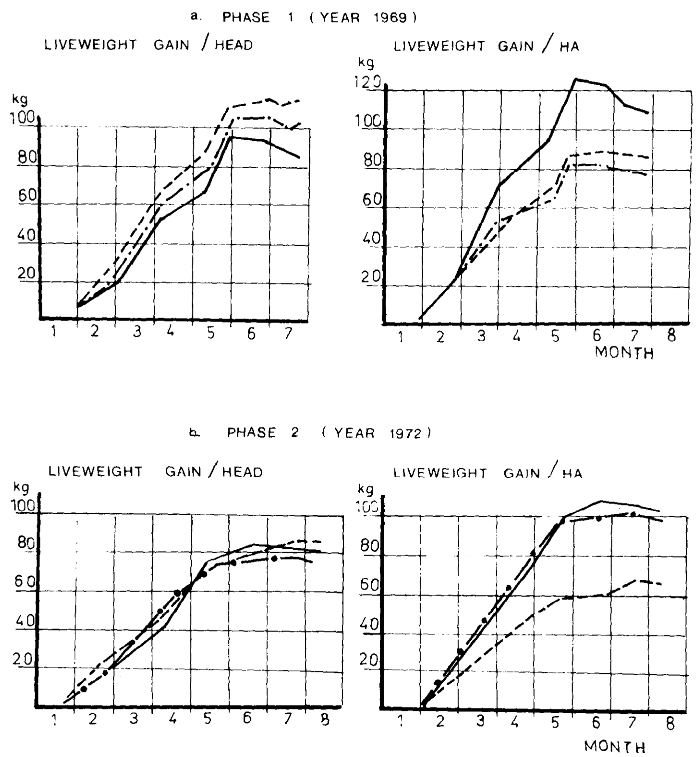

Fig. 2. *Average liveweight gain of dry beef cows in two seasons, representative of each phase of the experiment. Grazing treatments:* —·—·— *rotational moderate;* —o—o—o *rotational heavy;* - - - - - *continuous moderate;* ———— *continuous heavy.*

Table 3. Animal density and production parameters in the green and dry season.

Grazing treatment	Stocking rate (head.ha^{-1})	Grazing pressure (grazing days.ha^{-1})	Daily liveweight gain (kg head^{-1})		Daily metabolizable energy requirement (Mcals.head^{-1})	
			Green season	Dry season	Green season	Dry season
a. Treatment Phase 1 (1964-1970)						
Rotational moderate	0.8	150	0.72	0.04	17.0	11.6
Continuous moderate	0.7	140	0.76	0.04	17.5	12.0
Continuous heavy	1.2	236	0.69	−0.03	16.7	11.3
b. Treatment Phase 2 (1971-1973)						
Rotational heavy	1.3	253	0.52	−0.05	13.7	10.8
Continuous moderate	0.8	153	0.56	0.17	14.2	11.4
Continuous heavy	1.3	245	0.59	−0.06	14.5	10.8

stocked paddocks, the smaller amount of pasture biomasss which was available per head for grazing, rather than the length of the green season seemed to limit the total seasonal liveweight increase per head in both phases.

Liveweight Gain per Unit Area:

The liveweight gain per unit area was higher in the heavily stocked paddocks. The results of Phases I and II are similar: 61 and 64 kg·ha^{-1} in the moderate stocking densities and 83 and 94 kg·ha^{-1} in the heavy stocking density. Within the range of stocking densities applied in this trial, the liveweight increase per unit area was in almost direct relationship to the grazing pressure.

Pasture productivity in terms of utilized metabolizable energy (ME) is calculated as total requirements of the cattle for maintenance and liveweight gain during the grazing season. The results (Table 2) showed that the pasture productivity was higher in the heavy stocking density. At the heavy stock density, the productivity of range relative to moderate stock density did not decline after 10 consecutive years (Table 2).

If one adds the 10-year mean ME value of the residual litter at at the end of the grazing season (assuming 1.5 Mcal·kg^{-1} dry-matter, A.R.C. 1965) to the ME utilized, the difference between heavy and moderate grazing becomes very much reduced: 4300 Mcal·ha^{-1} in the heavy treatment and 3900 Mcal·ha^{-1} in the moderate. These results differ from those of many grazing trials conducted with similar vegetation in the western U.S.A. (Beetle et al. 1961; Klipple and Costello 1960; Launchbaugh 1957; Lewis et al 1956). The range productivity was relatively stable in spite of wide seasonal fluctuations in rainfall. The average ME utilised by the cattle during the grazing season in the heavy stocking density, was 3,350 Mcal-·ha^{-1} (S.D. ±340), with minimum and maximum values being 84.7% (1973) and 112% (1964) of the mean.

Cattle Responses to Rotational Grazing

The effect of grazing rotation on cattle and vegetation was studied under moderate and heavy stocking densities (Phase I and II, respectively). In both phases the liveweight increase per head was lower in the rotational than in the continuous treatments (Table 2). The results are similar to those obtained in grazing trials in the western U.S.A. (Heady 1961; Murray and Klemmedson 1968).

During the green season the cattle in the rotational grazing treatment gained slightly less per head than those in the continuous grazing treatment; the difference was not significant but fairly consistent (Table 3). It appears that toward the end of each grazing period, in each rotational sub-unit, the feed available during the green season was insufficient for the livestock to maintain their potential liveweight increase. During the same period, feed was abundant in the continuous treatment. As the animal density was the same in the two systems (rotational moderate compared with continuous moderate in Phase I, and rotational heavy compared with continuous heavy in Phase II) and the differences in liveweight increase per head were very small, there were no significant differences in the liveweight gain per unit area or in range production measured as metabolizable energy per unit area.

Vegetation Responses to Stocking Density

The botanical composition in all the paddocks at the beginning of the grazing treatment was similar (Fig. 3). During the first 2 years of the trial, no significant changes occurred, but after the third year the forbs began to increase in the continuous heavy treatment. As the relative cover of the forbs increased, the cover of the grasses decreased. After 5 years an equilibrium was reached and subsequently only small yearly fluctuations were observed. The relative cover of the legumes was not affected by the grazing treatments, but marked yearly variations occurred (Fig. 3), apparently due to the climatic conditions during seed set and germination (Quinlivan 1968). The amount of ungrazed vegetation at the end of the grazing season was greater in the moderate grazing treatment than in the heavy one (Table 2), but the amount of dead vegetation had no measurable influence on the growth in the subsequent season. Similar results were obtained by Weaver and Rowland (1952). At the beginning of the grazing season (January) the total cover of the herbaceous vegetation was similar in all the paddocks. No discernible influence of the grazing treatments was observed on the cover of

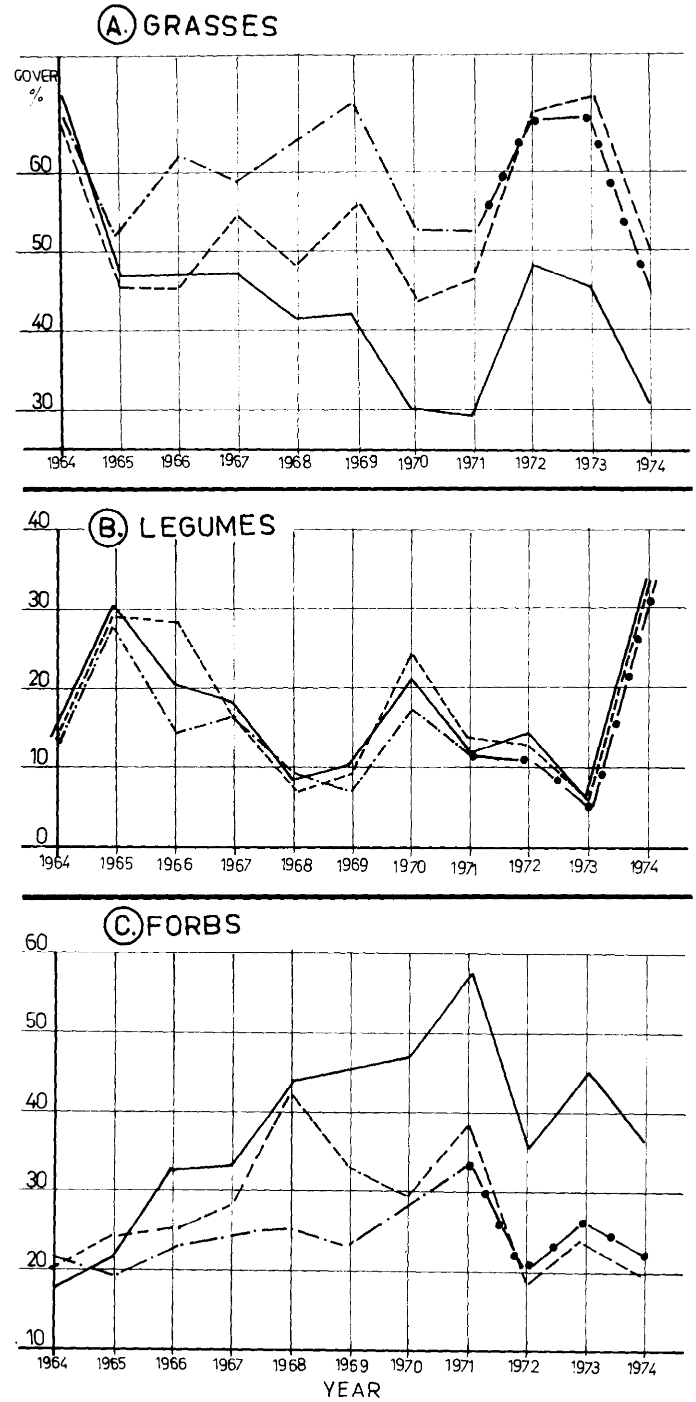

Fig. 3. *Effect of grazing treatments on botanical composition of the herbaceous sward. (Key to grazing treatments as in Fig. 2).*

the hemicryptophytic dicotyledons—*Psoralea bituminosa* and *Echinops viscosus*.

Vegetation Responses to Rotational Grazing

At the moderate stocking density, the relative cover of grasses was higher in the rotationally grazed paddocks than in the continuously grazed ones. At the beginning of Phase II (1971), the botanical composition in the paddocks with the heavy stocking treatments (rotational and continuous) was different, due to the different treatments in the preceding Phase I. Consequently, it is possible to compare the trend in botanical composition of the paddocks due to the change in treatments.

The relative cover of the grasses dropped when the stocking density in the rotational treatment was increased from moderate to heavy. After 3 years the relative cover of grasses was almost the same in the heavy rotational treatment (originally moderate rotational with high grass cover) as in the moderate continuous one. It appears that grasses persist better and even increase under rotational grazing compared with continuous grazing, but increasing stock density—even under rotational grazing—causes a reduction in the cover of grasses (Driscoll 1967; Rossiter 1952; Smith et al. 1967).

At the end of the grazing season there was consistently and significantly more litter in the rotationally grazed paddocks than in those grazed continuously. This appears to be due not only to more vegetative growth under the rotational treatment but also to the fact that the cattle apparently grazed less, as evidenced by the lower weight gains in these treatments.

Discussion and Conclusions

The heavy stocking density in this experiment was 1.2 dry cows $.ha^{-1}$ or 1.0 cow-calf units $.h^{-1}$ (Paulsen and Area 1962). Corrected for yearlong grazing, this is equivalent to about 0.7 cow-calf units a^{-1}, compared to 0.3—0.4 cow-calf units$\cdot ha^{-1}$ previously proposed for the region by the local extension service. Production under heavy grazing was maintained for 10 consecutive years. This result must be viewed in the light of the fact that the native vegetation has been grazed continuously since Biblical times (Seligman and Tadmor 1972). The species that have evolved and survived under these conditions can clearly withstand heavy grazing pressure. A very diverse flora—over 250 common species at Kare Deshe alone (Seligman and Gutman 1976)—must also contribute to the viability and flexibility of the vegetation under grazing.

The stability of the pasture productivity from year to year was due partly to deferring grazing for about 6 weeks after germination and partly to the length of the grazing season, which extended almost to the end of the dry period, when the plants are dead or dormant. As a result, the consumption rate of pasture during the green season (about 11 kg $.ha^{-1}.day^{-1}$) was much less than the growth rate throughout the period when it was grazed (20−100 kg$.ha^{-1}.day^{-1}$). The amount of dead vegetation had no measurable influence on the new growth in the subsequent season, so that heavy utilisation of the dry standing biomass increased rather than reduced secondary production. It should, however, be pointed out that the basaltic protogrumosol, with additional protection from the rock cover, is very resistant to erosion, and litter cover plays a small role in this regard.

The calves in the region are weaned during May-June. Most of the differences in live-weight increase per head between the continuous heavy and continuous moderate treatments occurred during July and August. It is thus likely that production would have been higher with suckling cows, even after correction for stocking density for the greater requirements of the cow-calf unit.

No important differences in cattle production per unit area between the rotational and continuous grazing systesm were observed. The principal possible advantage of the rotational grazing was the higher amount of ungrazed vegetation at the end of the grazing season that could have been utilised. At heavy stocking densities, it is thus possible to extend the dry grazing seasons in the rotationally grazed paddocks for a longer period than in the continuously grazed ones.

In some years the residual vegetation was grazed to obtain an estimate of its value. Daily intake of dry pasture was calculated by dividing the reduction in the amount of litter during the residual grazing period, (i.e. the difference in the amount of litter on the ground at the beginning and end of the period) by the number of grazing days in the same period. It was found that the cattle intake during the dry season was approximately 4–5 kg dry matter per head per day, about half that consumed per day in the green season. The amount of grazable vegetation left in the rotational heavy treatment, over and above what was left in the continuous heavy treatment, was 350 $kg{\cdot}ha^{-1}$ (Table 2). Accordingly, with 1.2 head $.ha^{-1}$ it was possible to graze another 5 days in the rotational treatment. Thus, when the animals are to be kept all the year long on the pasture, there is a possible advantage to rotational grazing that was not covered by this trial. However, for systems where seasonal use—especially green season use—is made of the pasture, there appears to be no obvious benefit from rotational grazing.

In the rotationally grazed paddocks, there wre more grasses and fewer forbs than in the continuously grazed paddocks. Nevertheless, the production in the continuously grazed paddocks did not drop in spite of the high proportion of forbs. Thus, in the Mediterranean steppe range, botanical composition alone is a poor indicator of the productivity of a pasture.

An important advantage of rotational grazing is that where fire is a hazard—as in our region—those paddocks most exposed can be grazed down early in the dry season. Thus, the choice of grazing system will depend on many factors: type of cattle, grazing season, fire hazard, herd management, etc.; but production from a given area seems to depend more on the animal density than on the grazing system.

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