STUDIES ON IMPROVEMENT AND UTILIZATION OF RANGELANDS OF JAISALMER REGION

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PREFACE

The Jaisalmer region covers an extreme arid tract of the Indian desert with sprawling natural grazing lands which constitute about 43 per cent of the total geographical area of western Rajasthan. Pasture based animal husbandry is the mainstay of the economy of the desert peasantry. Although the grass covers typified by *Lasiurus sindicus* and *Panicum antidotale* is highly adaptive as well as productive, it is in most of the areas, is by and large, in degraded conditions primarily due to past misuse and present neglect.

Carrying capacity of the grazing lands of the Jaisalmer region can be restored and improved further if suitable improvement and utilization practices are perfected and applied. It is in this context that Central Arid Zone Research Institute, Jodhpur established a chain of Range Management and Soil Conservation areas in Jaisalmer region at Lawan, Khetolai, Chandan and Jaisalmer all of which are located along Jodhpur-Jaisalmer highway.

Results of the studies on the improvement and utilization conducted in these Range Management and Soil Conservation areas of Jaisalmer region are described and discussed in this monograph. It is hoped that the information contained in the monograph will be of use to researchers, agriculture and animal husbandry agencies and to development planners of the Jaisalmer region.

Febr uary 1991

(J. Venkateswarlu)
Director

1. INTRODUCTION

Jaisalmer, the largest district of Rajasthan covers 38401 sq. km area and lies on the Indian part of the Thar desert (Fig. 1). The physiography of Jaisalmer, is heterogenous, e.g. barren rocky area, shifting sand dunes, sandy plains, saline flats, alluvial flats, dead streams and hills. The blown sand forms shifting sand dunes mostly in the north and the west. Some of the sand dunes in the south west are stabilized. As a result of the hostile agroclimatic conditions agriculture is at a low key, 5% in Jaisalmer (Ahuja, 1977). Crop cultivation being a gamble in the desert land the inhabitants take to the livestock farming. The region is the home of some of the best breeds of cattle, sheep, goat and camel. The livestock in this region are

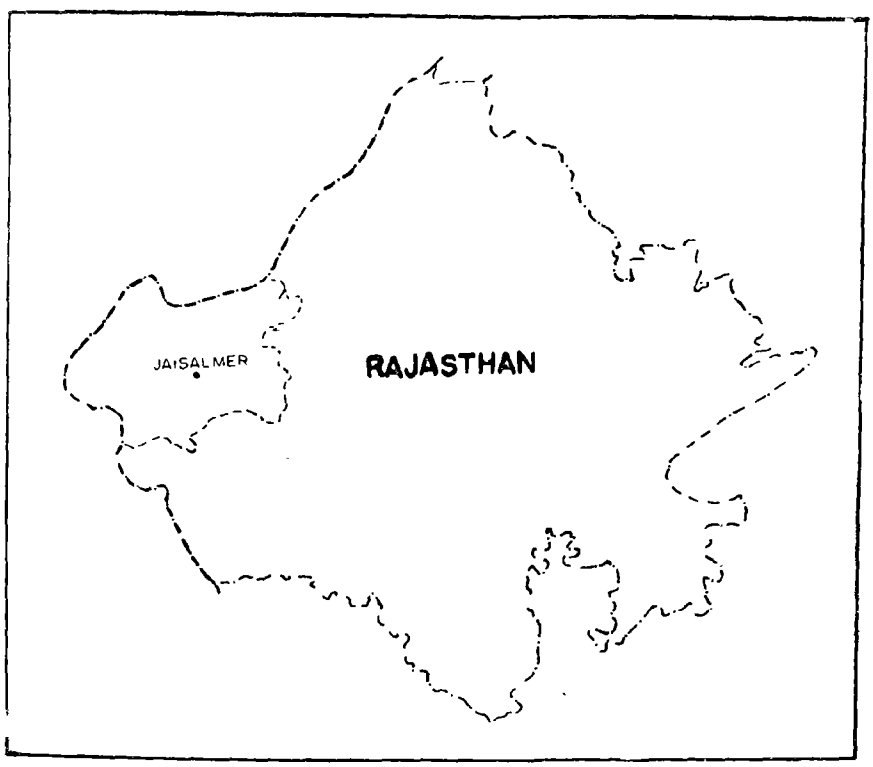

Fig. 1. Location map of Jaisalmer showing experimental sites.

hardy and highly productive; cows of Tharparkar and Kankrej breeds have high milk yield potential, i.e. 2000-2500 litres/lactation (Ahuja, 1977).

In years of normal rainfall the available forage from farming, cultivable wastes and fallows and pasture land is about 63.3 per cent of the total need of the existing livestock. The entire Jaisalmer district falls within acute drought and famine belt which makes it more vulnerable to scarcity conditions. The forage production is very low during the years of sub-normal rainfall. This entails transport of fodder from other States for the livestock survival and taxes the States and Central exchequer very much (Ahuja and Muthana, 1969). The livestock are also forced to migrate to other States where these get crossed with local mongrels resulting in the loss of breed pedigree, contact of diseases, reduction in livestock production potentials, reduced employment and less availability of milk and meat to the local population.

Due to increase in the human population there is a continuous encroachment on marginal and submarginal land for cultivation of cereals and legumes for human food. The number of livestock has increased at a higher rate in this district. The livestock population has increased from 6,11,191 to 13,00,459 and 16,64,389 in the year 1972, 1977 and 1983, respectively. Therefore, the gross area of grazing per unit of livestock will be reduced. In order to meet the conditions so circumscribed, the only resource left is to improve the existing grazing resources and increase their production (Mann, 1974).

Climate

The climate of this region is typically arid. The mean annual rainfall is 150 mm (average of 20 years, Fig. 2) which gradually decreases from the south-east to the north-west. Rain occurs from July to mid-September. Rainfall years of large deficit are more frequent in this region. The peak of rainy season invariably occurs during August. Winter rainfall is hardly 2-4 per cent of the total precipitation; and frost frequently occurs between mid-January to mid-February. Erratic and meagre rainfall is, thus, a serious constraint. The mean maximum temperature in this region in summer rises to 40°C. The highest temperature in this region ranges between 48 to 50°C (Krishnan, 1977).

Soils

The soils are mostly sandy with low water holding capacity. The desert soils developed in sandy interdunal areas of the western part are 50 to 100 cm deep and are dificient in nitrogen, carbon and mineral salts (Mertia 1976). The dune soil is generally composed of 63.7 to 87.3% fiine sand and 11.3 to 30.3% coarse sand with 1.8 to 4.5% clay and 0.4 to 3.1% slit (Dhir. 1977).

The sandy soil of the north, i.e. Pokaran and Nachna are known as *Chahi* and *Barani*.

Chahi areas are suitable for irrigation and produce a variety of crops. The soils of low lying areas or "*Khadeen*" are also suitable for cultivation. A major portion of area around Jaisalmer and Pokaran is rocky gravelly (locally known as "*bajaria*") are unsuitable for cultivation due to very poor soil depth and hard *kankar* pan.

Grass covers

Grass cover of the north-western part of the arid region of India is typified as *Lasiurus - Cenchrus – Dichanthium* type (Dabadghao and Shankarnarayan, 1973). In a reconnaissance survey of about 11,000 sq. km in Luni basin of western Rajasthan twelve pasture types were reported within this cover (Satyanarayan, 1964). Seven grass cover types have been reported in Indian desert (Gupta and Saxena, 1972).

The flora of this region is predominantly therophytic. Majority of species are annuals but a few perennial grasses make up the most important part of the vegetation of different habitats in the region.

Flora of Jaisalmer is constituted by 200 species, belonging to 127 genera and 49 families. Poaceae, Papilionaceae, Boraginaceae and Convolvulaceae constitute 75% of the flora. Poaceae is the largest family being represented by 20 genera and 34 species. Except Poaceae and Cyperaceae, monocotyledons are poorly represented. Dicotyledons are represented through 45 families, 104 genera and 159 species. Ratio of monocotyledonous to dicotyledonous species is 1:11 (Mertia, 1976).

Range condition classification

About eighty per cent of the grasslands in Jaisalmer region are under "poor" to "very poor" condition and are subjected to severe erosion hazards because of over grazing. Five conditions classes (Table 1) have been identified (Bhimaya and Ahuja, 1969).

Table 1. Different condition class of rangelands

Condition class	Forage production (kg/ha)	Carrying capacity (Acu/100 ha)
Excellent	over 1500 kg	25-30
Good	over 1000 kg	20
Fair	over 720 kg	17
Poor	over 500 kg	13
Very poor	over 200 kg	6

Forage grasses

Lasiurus sindicus Henr. It comes up on sandy soils, plain fields, sandy drifts and sand dunes with low precipitation (250 mm). Under well managed conditions it yields 4 to 5 t/ha dry forage during good rain years. It is highly palatable to cattle and sheep upto the flowering stage. But later on, in October it attains rank growth and becomes less palatable.

Cenchrus ciliaris Linn. It comes up well on light soils receiving 250 mm average annual rainfall. Its contribution to the forage biomass is not appreciable because of its low frequency in this tract. It is highly palatable at all stages of growth to all kinds of the livestock.

Cenchrus setigerus Vahl. It has low population density in this tract and is highly palatable to all kinds of the livestock.

Panicum antidotale Retz. Although this species comes up on sandy terrain, it performs well on sandy soils of 200 mm annual rainfall zone. It is relished upto the preflowering and the flowering stages by cattle and sheep. It is susceptible to moderate to heavy intensities of grazing. Dry forage yield of 2.5 tonnes/ha have been recorded in good rainfall years.

Dichanthium annulatum (Forsk.) Stapf. It is found only in areas where water accumulates, e.g. run off channels. It is highly palatable upto the flowering and the seedling stages.

Eleusine compressa (Forsk.) Aschers. & Schweinf. It grows well on shallow, gravelly soils in association with other perennial and annual grasses. It is palatable at all stages to cattle, goat and specially to sheep.

Cymbopogon jwarancusa (Jones.) Schult. It comes up in association with *Lasiurus sindicus* and *Cenchrus* spp. on rocky to sandy terrain particularly in run off channels. Its palatability is rather poor. It is used for thatching of animal sheds.

Panicum turgidum Forsk. It is a dominant grass on transverse dunes and is associated with *Lasiurus sindicus* on shifting sand deposits. It is highly palatable upto the preflowering to the flowering stages.

Dactyloctaenium sindicum Boiss. It is a perennial, creeping grass occurring on gravelly rocky habitats in large patches. It is palatable to cattle, sheep and goat.

Eragrostis diarrhaeha (Schult.) Steud. It is a gregarious perennial grass and grows in wet clayey soils and also on bunds. It is highly palatable to cattle sheep and specially to horses. A large pasture of this grass was established at village Deva in Jaisalmer, particularly for horses.

Oropetium thomaeum (Linn, f.) Trin. It is pioneer coloniser on rocky, gravelly soils and is low set grass grazed upon by sheep.

Aristida species There are eight species of this genus found in rocky, gravelly and s' allow soils. It is palatable when young. Thereafter awns develop making it unacceptable.

Cenchrus biflorus Roxb. It is palatable until middle of August. Thereafter burrs develop which cause discomfort to the grazing animals. As compared to the cattle it is less palatable to the sheep and goat.

Chloris virgate Sw. It comes up on saline soils and water lodged areas. It is not

a common grass of this region, and as such occurs in patches in run-off channels, along with *Dichanthium annulatum.*

Eragrostis unioloides (Retz.) Ness. ex. Steud. It comes up on light to medium soils in comparatively higher rainfall zone. It is found on run off channels and is palatable at all the stages of growth.

Brachiaria ramosu Griseb. It is not a common species but highly palatable to all kind of animals. It comes on sandy soils.

Latipes senegalensis Kunth. It is an annual found in areas of even below 200 mm rainfall. It is a common species on rocky and gravelly habitat. It forms flat cushioned patches. It is more palatable to the sheep.

Enneapogon elegans (Ness ex Steud) Stapf. It is a pioneer coloniser on gravelly habitat sometimes occurring on rocks too. It grows on slopes particularly forming a close gregarious association. It looks elegant due to its pinkish spikes. It is more palatable to the sheep.

Indigofera cordifolia Heyne ex Roth. It is a dominant legume of the arid rangelands. As compared to sheep and camel it is less palatable to cattles. It is highly palatable at all stages of the growth. It is stacked for stall feeding during lean period and fed in mixture along other feeds, viz. threshed grass, pala and loong, etc.

Tribulus alatus Delile. There are two species of this genus. It is common on sandy, gravelly, shallow soils. The winged seeds are nutritious. It is stacked to feed camels, sheep and milking cattle during the lean period.

Boerhaavia elegans Choisy. A sommon species of arid rangelands which comes up well under low precipitation (200 mm). It grows well on rocky and gravelly habitats. It is palatable to all kinds of animals.

Aeluropus lagopoides (Linn.) Trinn. ex. Thw. A small, sized erratic, very rigid perennial herb. It is restricted to saline areas wherein its close associate include *Cressa cretica* and *Genogyna hirta.* It is highly palatable to sheep.

Glinus latoides Linn. It is a prostrate, spreading annual herb and commonly occurs on drying margins of tanks and water logged areas along with *Vahlia dichotoma* and *Heliotropium supinum.* It is palatable to cattle, goat, sheep and camel. It is collected by sheep breeders for stall feeding.

Primary production

Studies on primary production at four range management areas, over a period of 20 years have provided very useful information on different aspects of range management for increased primary productivity which are given in brief.

With adequate protection, grazing the rangelands on the carrying capacity basis, aiming at 70 per cent utilization for the period of two years, forage yield increased by 148.3, 91.9 and 116.3 per cent in poor, fair and good rangelands, respectively. Good condition class rangelands were achieved after a period of 10-12 years in this

region. Thereafter, productivity to an extent of 2.5 to 3.5 tonnes/ha/year could be achieved from these rangelands.

Soil and water conservation measure, contour furrows on rangelands with shallow soils and rolling topography increased the forage yield by 638.7 per cent (from 212.7 to 1566.2 quintal/ha) over a period of ten years in arid rangelands.

Reseeding the natural rangelands in this tract with *Lasiurus sindicus* led to high forage yield. The maximum air dried forage yield of 6.5 tonnes/ha could be obtained from a well established strips of *Lasiurus sindicus*.

Studies on response to fertilizer application; 20 kg N/ha appeared to be beneficial in arid regions with low precipitation.

Studies on introduction of perennial legumes in arid rangelands have revealed that none of them could establish. However, *Dolichos lablab* performed better over other legumes but being annual it requires reseeding every year.

It is advisable not to graze the reseeded rangelands during the first year of establishment. After the entire area of the rangeland is well established as a result of self seeding, it is advisable to utilise it rotationally.

Different system of grazing, revealed beneficial effect of deferred rotational grazing and partial harvesting on range composition and production as compared to continuous controlled grazing system.

2. RANGE IMPROVEMENT

With a view to establish scientific methods of upgrading and utilization of existing rangelands, studies were undertaken in the Range Management and Soil Conservation Centres of Jaisalmer tract, since 1959 with the following objectives :

1. To find out different management techniques of improving natural rangelands.
2. To evaluate suitability of various grasses, legumes and fodder trees and their compatability.
3. To evaluate economic soil conservation measures.
4. Evaluation of different grazing systems on various types of rangelands for optimum livestock production.
5. Collection of seeds of perennial grasses for reseeding rangelands.

Site Selection

Lands falling under land capability class V to class VII are unfit for crop cultivation and those under class IV are subjected to wind and water erosional hazards. It will be desirable to utilize these land types for development projects. The local people can visit these projects frequently and realise the importance of such development works.

Protection (Fencing)

No land development project in this part of the country will succeed without proper protection as there is heavy pressure of livestocks. Amongst the different types of fencing tried, the one with angle iron post and barbed wire is the most effective, long lasting and economical in the long run though initially costly. Cost of different type of fencing is given in Table 2.

Fencing, other than angle iron post and barbed wire, need frequent reinforcements. The cost of angle iron post and barbed wire fencing is inversely proportional to the size of blocks; the cost per hectare in blocks of 40, 100, 200, 500 and 100 hectares worked out to Rs. 530/-, 363/-, 240/-, 160/- and 110, respectively (Ahuja, 1974). With adequate protection and grazing (70 per cent utilization for the period of two years) forage yield increased by 148. 3, 91.9 and 116.3 per cent in Poor, Fair and Good rangelands, respectively. Poor condition class rangelands reached good condition in period of 10-12 years (Tables 3 & 4). Thereafter, forage production stabilized with little fluctuations over years.

Table 2. Initial and maintenance cost of different types of fencing in rangelands (Paroda *et al.*, 1980)

Particulars	Cost per running metre	
	Initial	Recurring (Per year)
Angle iron post and barbed wire fencing	8.00	0.15
Angle iron and wooven wire	10.62	0.19
Stone post and barbed wire	10.81	0.24
Wooden post and barbed wire	8.28	0.29
Core well fencing	4.87	1.17
Ditch and core wall fencing	2.83	0.73
Stone wall fencing	4 43	2.40
Cactus fencing	4 97	0.78

Table 3. Average dry forage yield (kg/ha) on rangelands of Jaisalmer region during 1961 to 1972.

S. No.	Range Management Areas	Soil type	Grass cover	Average forage yield (kg/ha)
1.	Jaisalmer	Sandy-Rocky	*Lasiurus sindicus* *Cymbopogon jwarancusa* *Aristida* spp.	473
2.	Chandan	Sandy	*L. sindicus* *Aristida* spp.	424
3.	Khetolai	Gravelly	*Aristida* spp. *Cenchrus biflorus*	334
4.	Lawan	Gravelly	———do———	339

Table 4. Average dry forage yield (kg/ha) on rangelands of Jaisalmer region during 1972 to 1981

S. No.	Range Management Areas	Soil type	Grass cover	Average forage yield (kg/ha/yr)
1.	Jaisalmer	Sandy-Rocky	*Lasiurus sindicus* *Eleusine compressa*	927
2.	Chandan	Sandy	*L. sindicus*	1754
3.	Khetolai	Gravelly-Sandy	*L. sindicus* *E. compressa* *Cenchrus biflorus*	1500 1163
4.	Lawan	Gravelly-Sandy	———do———	

Bush Control

Unwanted shrubs like *Lycium barbarıum, Mimosa hamata, Leptadaenia pyrotechnica* and *Maytenus emarginata* hinder the growth of grasses and are troublesome

for cattle and sheep. Application of 2-4-5 T (Trichloro phenoxy acetic acid)' immediately after cutting away aerial parts of shrubs (Dabadghao, 1969) provided an effective control. Even useful top feed species like *Ziziphus nummularia* should not have crown cover of more than 14% in rangelands (Ganguly *et al*, 1964).

Soil conservation measures

The class IV to VIII land of the range management areas was highly eroded with exposed rocky surfaces, stones and boulders. Soil conservation measures specially on land forms with shallow soils and rolling topography was essential. The two range management areas, i.e. Jaisalmer and Lawan with gravelly barren shallow soils were protected with ditch and mound fencings (about 500 m apart) in 1959, followed by construction of contour furrows of 929 m^2 cross section spaced at 8 to 10 m. Mounds of contour furrows and fencing trapped sand and on it *Lasiurus sindicus*, annuals and ephemerals appeared. The forage yield increased six times in 9 years (Ahuja *et al.*, 1973). This indicated that shifting sand and the rangelands under poor condition, if managed and developed can prove potential source of forage production (Table 5).

Table 5. Air dried forage (kg/ha) under contour furrowing

	Contour furrowing			
Year	Treated	Control	Difference	% increase
1961	796.2	257.0	539.2	230.2
1962	2297.0	212.0	2085.0	963.4
1963	647.6	65.5	582.1	888.4
1964	1951.0	110.0	1841.0	1673.6
1965	2293.3	234.3	2059.0	878.7
1966	2328.1	255.3	2072 8	811.9
1967	1741.0	434.4	1306.7	360.8
1968	317.8	27.6	354.2	2012.5
1970	1669.8	328 4	1341.4	403.4
Mean	1566.2	212.7	1341.4	638.7
SEm ±	183.2			
F. Test	Highly significant			
C.D. at 5%	547.6			
1%	754.5			

Reseeding

Natural succession of desired species is a very slow process. Hence, reseeding the natural grasslands with suitable grass species suiting the agroclimatic conditions is the only answer. This involves (1) grubbing of unwanted bushes, (2) land preparation. In this area, with shifting sands, very light soil working is needed. Due to erratic rainfall conditions and poor germination of seeds of *Lasiurus sindicus*, sowing of a mixture of seeds as recommended by Ahuja and Bhimaya (1967) was tried but it did not give

encouraging results. In order to have better results of reseeding the grass seed should be pelleted (Chakravarty and Bhati, 1969). Pellets are prepared by mixing grass seeds with, cow dung, silt or clay and sand in proportion (by volume) of 1:1:3:1 using sufficient quantity of water for preparing spherical pellets of about 1 cm diameter with each pellet containing 2 to 3 spikelets (seeds). The pellets should be sown in line 60 to 75 cm apart taking care that pellets are not placed more than 1 to 2 cm deep in the soil. On dunes spot sowing may be done. Sowing operation should be carried out just before or immediately after the rains. It is advisable to plant rooted slips of *Lasiurus sindicus* from the nursery. Rooted tillers taken out from a good established clump of *Lasiurus sindicus* has also lead to good establishment and survival at Chandan.

Selection of improved strains

Five strains of Sewan, viz CAZRI 317, 318, 319, 353 and 565 were evaluated at Jaisalmer. The forage production over five years was significantly ($P < 0.01$) higher in strain No. CAZRI 353 compared to the other strains except CAZRI 565 (Table 6). However, high forage production potential of these two strains was not reflected in the yield attributes, viz plant height, basal area and til'er number, probablly because of the tiller wodiness observed in these strains (Mertia, 1986).

Table 6. Yield attributes of *Lasiurus sindicus* strains and environment effect

	Plant height (cm)	Basal area of clump (cm2)	Tillers (no)	Forage yield
	YIELD ATTRIBUTES			
L. sindicus 317	86.2	119.1	32.7	9.9
L. sindicus 318	98.9	158.4	88.7	10.6
L. sindicus 319	91.2	100.1	49.0	9.9
L. sindicus 353	88.1	142.6	56.3	15.5
L. sindicus 565	65.1	96.2	35.3	13.6
CD 5%	13.5	30.8	10.3	2.2
CD 1%	18.8	42.7	14.4	2.9
	ENVIRONMENTAL EFFECT			
Year				
1976	61.3	34.8	5.8	—
1977	87.3	184.5	99.4	9.0
1978	109.1	150.0	52.2	19.7
1979	—	—	—	12.7
1980	—	—	—	6.1
CD 5%	10.5	23.8	8.0	1.9
CD 1%	14.6	33.1	11.1	2.6

The environmental effect on the forage production of *L. sindicus* strains was also significant ($P < 0.01$) By and large, yield attributes of the strains did not very signific-

antly but the forage production of strain No. 353 and 565 was higher over other strains. The seed multiplication programme can provide seed of desired strains for range reseeding.

Weed control

The reseeded rangelands need two weedings in the first year of the establishment (Chakravarty and Verma, 1972). It is advisable not to graze the reseeded rangeland in the initial or the 2nd year (depending upon rainfall and regeneration of vegetation). After the establishment of perennial grasses rotational grazing system should be practiced.

For this purpose natural grassland should be divided into four compartments. One paddock should be kept as a "reserve pasture" by turn every year and grazing in the remaining three compartments should be carried out at a monthly rotation.

Legume introduction

Introduction of legume is a very important aspect of improving the low nutritional status of forage for livestock. Studies conducted on the performance of legumes like *Dolichos lablab Atylosis scarbaeoides, Clitoria ternatea, Vigna sinensis, Cyamopsis tetragonoloba* and *Phaseolus aconitifolius,* revealed that perennial legumes except for *Dolichos lablab* failed to establish and were susceptible to frost and failed to produce seeds. The main reason for this is the scanty and highly erratic rainfall distribution.

Forage conservation and preservation

Recurring droughts are common feature in this tract which result in shortage of forage. To overcome this problem, conservation of grass is most essential moreover, it has also been experienced that the livestock generally start losing weight from November onwards which obviously is a reflection of decline in the quality of growing forage (Fig. 2). Timely harvesting and the preservation of forage will ensure both the quality and the regular supply of forage. For better results, grass should be harvested at pre-flowering stage in the morning hours and kept for sun drying. When kept dry in stack, hay will invariably store well for long, without any further decline in quality. It can also be utilised for stall feeding during the lean period from December to June to productive stocks (Fig. 3).

Fertilizer application

The nutrient content and production potential of forage species on the rangelands in western Rajasthan is quite low (Paroda *et al.*, 1980) and therefore, for optimum production, it is essential to add fertilizers to the soil. Three different levels of fertilizer application were tried at the four range management areas, (1) 20 kg N/ha, (2) 20 kg N + 20 kg P_2O_5/ha, and (3) 40 kg N + 20 kg P_2O_5/ha. The response of only 20 kg /N/ha appeared to be favourable in arid rangelands receiving less than

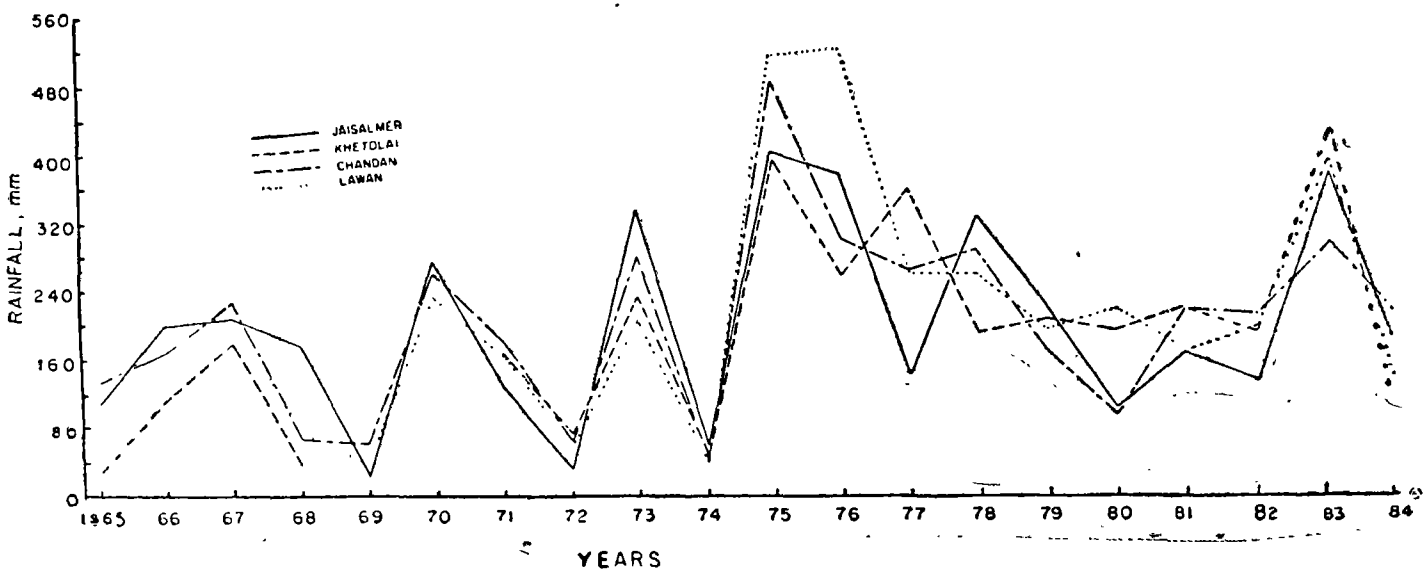

Fig. 2. Annul rainfall distribution at four experimental sites (1965 to 1984).

Fig. 3. *Lasiurus sindicus* hay for feeding cattles during lean period.

250 mm annual precipitation. Fertilizer application increased the yield of crude protein in *Lasiurus sindicus* by 82 per cent (Das *et al.*, 1964). Due to improvement of native rangelands, with these techniques their carrying capacity can be increased 4 to 6 times. It is further observed that in Jaisalmer district much more land is available for rangeland development. If the existing rangelands are improved, the shortage of forage can be reduced from 39.3 per cent to 2.5 per cent.

Silvi-pastoral management

It is necessary that a 'good' condition grassland should have 25 to 30 useful trees per hectare to provide feed, shade and minor timber and browse during the lean period. Introduction of suitable leguminous trees will not only provide nutritionally better quality fodder during the lean period, but will also be useful in nitrogen build-up in the soil and will provide shade to the grazing animals. In addition, fodder trees and shrubs will ameliorate the micro-climatic conditions and thereby improve conditions for better regeneration of grasses.

Introduction of indigenous and exotic trees and shrubs in these rangelands was initiated in 1978 with species viz. *Acacia tortilis*, *A. anura*, *Azadirachta indica*, *Dicrostychis nutans*. *Albizzia* labbeck, *colophospermum mapone*, *Leuceana leucocephala* and *Prosopis juliflora*. Study based on six years performance of these species revealed that *Acacia tortilis*, *Azadirachta indica*, *Dicrostychis nutans* and *Colophospermum mopane* were superior to other species in growth, survival and resistance against drought and frost.

3. RANGE UTILIZATION

Harvesting

With proper management the production of these highly denuded rangelands can be increased substantially (from 200 kg/ha to 3 to 4 tonnes/ha air dried forage) in years of normal rains. Since, recurring droughts are common in this region and cause shortage, of forage conservation of fodder is essential. Moreover, the fact that the livestock generally start losing body weight from November onwards is a reflection of decilne in the quality of forage. Harvesting of forage at the preflowering stage will ensure regular supply of quality forage.

Grazing

Best way to utilize the natural rangelands is through controlled grazing based on carrying capacity. Therefore, a balance between the productivity of rangelands and the number of grazing animals need to be maintained by continuous and careful observation on peak forage production, morphological and physiological characters of the range vegetation. In this region due to highly erratic rainfall, the forage production of rangelands varies from year to year and so a relatively low stocking rate is needed to avoid overgrazing. The stocking rate can vary within the region depending upon the habitat and the vegetation type of the rangeland, but the objective always should be to achieve efficient utilization of the forage available while aiming at improvement of the range condition.

Rangelands of *Lasiurus sindicus* having productivity of 20, 15, 10, 7.5 and 5.0 quintals/ha have been classified as Excellent, Good, Fair, Poor and Very Poor which can sustain on yearlong basis, 25-30, 20, 17, 13 and 1-6 adult cattle units per 100 ha, respectively during the normal rain years (Bhimaya and Ahuja, 1969). Grazing saves cost of harvesting of short grasses and low yielding annuals. The grazing livestock while moving disturb the soil through their hooves, break-up the top crust of the soil, and thus improve percolation of water for plant use and better forage production. Their excretion, i.e. dung and urine add to the plant nutrient contents of soil and thus improve its fertility.

For grazing, rangelands with dominance of *Lasiurus sindicus* or reseeded rangelands, the area may be divided into four compartments, i.e. A, B, C and D and four

years cycle of rotational grazing may be carried out (based on carrying capacity) as per schedule given below :

Year of grazing	Grazing month of year and paddocks						Reserve paddock
	Aug., Feb.,	Nov., May	Sept., Mar.,	Dec., June	Oct., April,	Jan., July	
1st year	A		B		C		D
2nd year	B		C		D		A
3rd year	C		D		A		B
4th year	D		A		B		C

Suitable animal species

The choice of introduction of animal species depends upon the botanical composition of a rangeland. For efficient utilization and optimised livestock production animal species for rangelands with *Lasiurus sindicus*, *Lasiurus-Eleusine-Aristida* and bushes, thorny vegetation, cattle, sheep and goat, are suitable.

Drinking water

For any rangeland development adequate arrangements for drinking water is essential. Drinking water is one of the main limiting factors for proper livestock production. For want of the drinking water the vast area around Nachna, Mohangarh, Shahgarh, Ghotaru and Asutar region supporting *Lasiurus sindicus* remain unutilized. Till some permanent arrangements of water supply is made it is advisable to provide underground water reservoirs (Tanka) for animal and human consumption. A Tanka with a capacity of 200 kilolitres is sufficient for 100 hectare of good condition class of rangeland (Prajapati *et al.*, 1973).

Daily requirment of drinking water for farm animals on the range during different months of the year are shown in (Fig. 4). The observation in respect of yearling heifers and ram lambs revealed that intake of water during monsoon, autumn and winter seasons is low as compared to summer season. The quality of water in this region is brackish in border areas. Sheep can survive 25 per cent reduced supply of normal needs even during summer but for restricted periods (Purohit *et al.*, 1973).

Health care of the livestocks

Due to inadequate veterinary facilities in the arid area and the vast grazing lands, treatment of sick animals is difficult. It is advisable, as is the practice followed on these managed rangelands for high livestock production and to avoid animals losses, to adopt prophylatic measures to ward off diseases. The common diseases in cattle of this region are Rinderpest, Haemorrhagic septicimia, Black Quarter and a disease locally known as Karah (Epidermal fever). In sheep Tympany, Enterotoximia and sheep pox are common. It is very essential to carry out periodic vaccination and deworming of all farm animals twice a year.

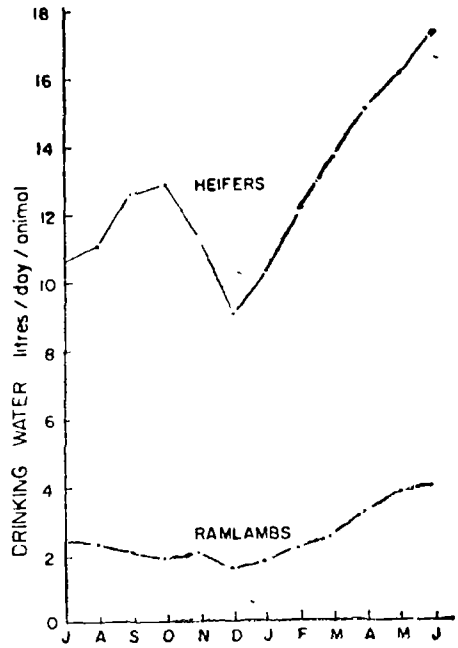

Fig. 4. Drinking water consumption by heifers/ram lambs during different months of a year.

In this region it has been observed that animals are deficient in minerals and phosphorus in particular. It is advantageous to provide mineral mixtures in feeds and mineral salt licks. The mortality is reduced and returns from the livestock increases (Ahuja and Bhatia, 1969).

Grazing systems

Different systems of grazing and grazing management practices were evaluated in different types of rangelands. The results of these studies are reported here.

At Jaisalmer

Different systems of grazinh by cattle

The *Lasiurus-Eleusine-Aristida* type of range land was put to grazing by cattle as per following grazing treatments

T_1= Continuous grazing on year long basis.

T_2= 2:2:2:2:2 months deferred rotational grazing. Early deferment (T_2 P_1) grazing during October-Novèmber, February-March and June-July. Late deferment (T_3 P_2) grazing during August-September, October-November and April-May.

T_3= 4:4:2:2 months deferred rotational grazing. Early deferment (T_3 P_1) grazing during December-January, February-March and June-July. Late deferment (T_3 P_2) grazing during August-September, Octobr-November and April-May.

T_4= 2:4:4:2 months deferred rotational grazing. Early deferment (T_4 P_1) grazing during August-September, February-March and April-May. Late deferment (T_4 P_2) grazing during October-November, December-January and June-July.

The body weight gains were significantly higher in animals under continuous controlled grazing (T_1), i.e. 68.52 and 71.80 kg/animal during the study period 1966-67 and 1967-68, respectively (Table 7) over other grazing treatments (deferred-rotational grazing) preferably because of continuous availability of green forage and higher utilization than other treatments. In the deferred rotational treatments the forage available to animals was comparatively less green and of low nutritive value. The higher body weight gains in T_1 was followed by T_3, over T_2 and T_4.

Table 7. Average body weight gains kg/heifer (Tharparker breed) under different grazing treatments

	1966-67			1967-68					
Treatment	Initial weight	Final weight	Gains	Initial weight	Final weight	Gains	SEm	'F' test	C.D. at 1%
T_1	87.12	155.64	68.52	95.00	166.80	71.80			
T_2	84.76	1.4.90	50.14	84.00	123.00	39.00	+3.14	Sig.	13.50
T_3	84.80	140.00	55.20	88 20	144 00	55.80			
T_4	84 80	140.08	55.28	88.20	144.00	55.80			
SEm ±	1.99	'F' test : N.S. C.D. at 1%							

Continuous grazing (T_1) deferred grazing with fixed number of animals on an unit area in half of the grazing period, i.e. two months alternate grazing (T_3 P_1 and T_2 P_2) without any specific provision for seed production two months (T_2 P_2 T_4 P_1) or four months, viz., August-November (T_3 P_1) as it allows the forage plant community to complete the life cycle and produce sufficient seed for future regeneration. Moreover, the production from vegetative parts is not disturbed and the desirable species compete well to keep down the less desirable ones. The animal production was significantly higher under continuous grazing (T_1); it was steady consistant and less fluctuating only in T_3 slow and steady gain in animal production are desirable than fluctuating higher gains (Prajapati, 1970).

It can thus be concluded that in arid rangelands early grazing is detrimental to the range vegetation as compared to early deferment of grazing during monsoon and spring seasons. Early deferment of four months, August to November is beneficial for regeneration of range vegetation.

At Jaisamler and Lawan

Mixed grazing by cattle and sheep

The rangeland under study at Jaisalmer comprised of an area of 45 ha and 80 ha at Lawan and was divided into five equal paddocks of 9 ha and 16 ha for each pastoral treatments.

T_1= Grazing on yearlong basis with 4 yearling heifers.

T_2= Grazing on yearlong basis with 16 yearling ram lambs.

T_3= Grazing on yearlong basis with 1 heifer + 12 ram lambs.

T_4= Grazing on yearlong basis with 3 heifers + 8 ram lambs.

T_5= Grazing on yearlong basis with 3 heifers + 4 ram lambs.

The stocking rate was high at Lawan area.

Maximum body weight gain per unit of area in heifers has been observed in T_1, i.e. 23.51 kg/ha the body weight gain per unit of area were higher with proportionate increase in the number of cattle rather than sheep on this type of rangeland. The body weight gain was lowest with the grazing of sheep in T_2, i.e. 18.17 kg/ha (Table 8).

Table 8. Growth performance of heifers and sheep under mixed grazing at Jaisalmer Animal production in different years (kg/ha)

Treatment	Year				Total	Gain in wt. (kg/ha)	Secondry production (gm/day/animal)
	1978-79	1979-80	1980-81	1981-82			
T_1	34.00	32.03	14.49	12.75	94.06	23.51	6.5
T_2	21.86	24.35	11.55	14.93	72.69	18.17	4.9
T_3	22 22	27.84	10.74	14.68	75.48	18.87	5.2
T_4	26.94	28.47	12.49	14.24	81.84	20.46	5.6
T_5	33.84	29.67	12.18	15.23	90.92	22 73	6.2

The maximum body weight gain in case of sheep has been observed in T_2 where the grazing is only by sheep i.e. 10.22 kg/animal on yearlong basis based on four years observation. It was followed by T5 where the number of sheep was lowest, the gains were 10.07 kg/animal followed by T4.

The comparative study on the growth performance of heifers and sheep in *Lasiurus Eleusine - Aristida* rangeland has revealed higher body weight gain in (T_1) followed by (T_5) indicating that the growth per hectare was higher with proportionate higher number of heifers. The least body weight gain was obtained in (T_2), i.e. 18.17 kg/ha with sheep grazing.

Another interesting feature was that sheep gained higher body weight in (T_2), i.e. 10.22 kg/animal over the other combination with heifers (Table 9) presumably because of close grazing habit in group rather than grazing along with other animals.

The major grass species, viz. *Lasiurus sindicus, Eleusine compressa, Dactyloctenium sindicum* and *Cymbopogon jwarancusa* survived the impact of selective grazing. There wa a decreasing trend in the percentage basal cover of *Lasiurus sindicus* in the pastoral treatment where there was higher number of heifers, i.e. (T_1) and (T_5). It has

Table 9. Comparative performance of heifers and sheep under mixed grazing at Jaisalmer

Treatment	Year				Total	Average gain in body wt.	
	1978-79	1979-80	1980-81	1981-82		Heifer	Lamb
T_1 Heifer	78.3	74.3	32.6	28.7	213.9	53.47	—
T_2 Lamb	12.3	13.7	6.5	8.4	40.9	—	10.22
T_3 Heifer	68.0	79.0	29.5	32.5	209.0	52.25	—
Lamb	11.0	14.3	5.6	8.3	39.2	—	9 80
T_4 Heifer	70.7	74.5	30.2	31.7	207.1	51.77	—
Lamb	11.8	13.4	6.5	8 1	39.8	—	9.95
T_5 Heifer	84.6	71.6	28.4	37.3	221.9	55.47	—
Lamb	12.7	14.3	6.1	7 2	40.3	—	10.07

indicated decrease from 6.60 to 3.63 and from 4.87 to 3.81 per cent respectively in the period from 1977 to 1980 (Table 10).

In the grazing treatments involving large number of ram lambs the cover of the annual legume *Indigofera cordifolia* declined over the years. This legume is reported to be highly palatable to sheep (Chakravarty *et al.*, 1970). Change in the percent basal cover due to treatments was highly significant where as frequency was affected significantly over the years.

Similar, results have been observed in this experiment at another site Lawan.

At Chandan and Khetolai

Continuous v/s deferred rotational grazing by cattle

Grazing by cattle on *Lasiurus Eleusine* rangeland as per following treatments during the period 1978 to 1982 was conducted.

T_1= Continuous controlled grazing
T_2= Deferred rotational grazing at an interval of one month.

The study revealed that there is no significant difference in the body weight gain in the animals grazing under continuous and deferred rotational grazing system (Table 11). The maximum body weight gain in animals have been observed in the period, August to October, i.e. 406 g/day/animal when the rate of growth is maximum (Figs. 5 & 6) and the animals start losing there body weight in the lean season (December to June).

The cows grazing on managed rangeland at Chandan have indicated higher gains over local grazing animals over the same period. Early conceivement and higher milk production in Tharparkar cows under managed grazing was observed. For early pregnancy of heifers and calving of Tharparkar heifers deferred rotational grazing

Table 10. Change in the percent cover of six grass species in three years (1977-1980) under different stocking treatments at Jaisalmer.

Species	Percent cover in different treatments									
	T1		T2		T3		T4		T5	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Lasiurus sindicus	6.60	3.63	2.89	2.74	1.31	1.71	3.81	3.56	4.87	3.81
Eleusine compressa	0.26	0.37	0.71	0.93	0.80	1.27	0.35	0.45	0.55	0.68
Dactyloctenium sindicum	0.02	0.03	0.05	0.01	0.26	0.09	0.14	0.07	0.03	0.01
Aristida funniculata	0.02	0.03	0.22	0.07	0.19	0.10	0.01	0.01	0.00	0.01
Cenchrus biflorus	0.01	0.01	0.01	0.03	0.01	0.00	0.00	0.01	0 00	0.01
Indigofera cordifolia	0.02	0.05	0.01	0.00	0.07	0.00	0.03	0.01	0.05	0.07

SEm for treatment ± 0.0548

'F' test	H.S.
C.D. at 5%	0.1539
1%	0.2134

H.S.=Highly significant.

Table 11. Growth performance of heifers/cows under continuous and rotational grazing system at Chandan, (gain in weight kg/year)

Grazing system	Year				Total	Average
	1978-79	1979-80	1980-81	1981-82		
T_1 Continuous controlled grazing	25.40	64.40	64.60	28.40	182.50	45.70
T_2 Deferred rotational grazing	34.80	54.40	58.40	28.20	175.80	43.95

system appeared superior to the continuous grazing system (Shankarnarayan *et al.*, 1981).

This study was continued for second lactation in Tharparkar heifer/cows and an attempt was made to evaluate economic viability of milk production on the pasture lands under extremely arid conditions. It can be seen from the results presented in Table 12 that NPV stood at more than Rs. 13,000 for Tharparkar cows. Negative NPV was attained at 40 per cent of discounting. In the final analysis of IRR greater than 14 per cent and PBP for not more than 6 years conclusively proved that long term investment was endowed with strong financial viability of herd management at Chandan (Kalla *et al.*, 1987).

Continuous v/s diferred rotational grazing by sheep

Grazing by sheep on *Lasiurus-Eleusine* type of rangeland was practised during 1978-1980 as per following grazing treatments.

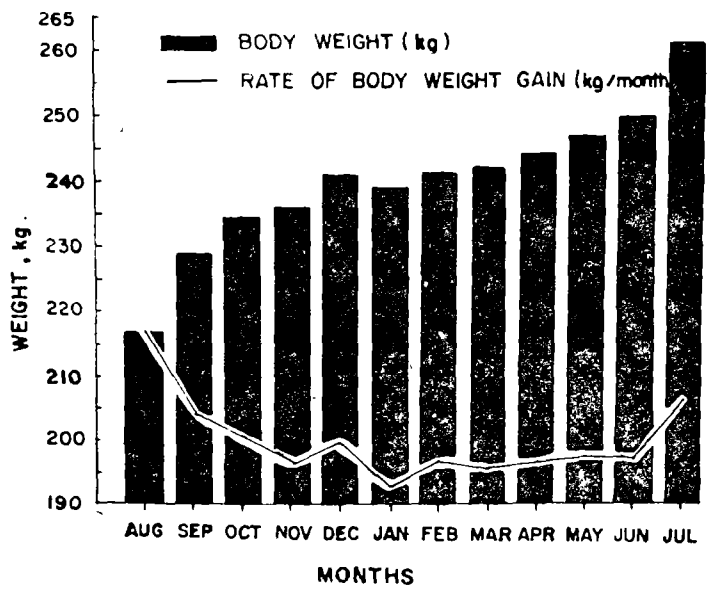

Fig. 5. Trend of body weight gain of Tharparker cows grazing on managed rangeland.

T_1 = Continuous grazing on yearlong basis.

T_2 = Grazing during first fortnight of August, October, December, February, April and June.

T_3 = Grazing during second fortnight of August, October, December, February. April and June.

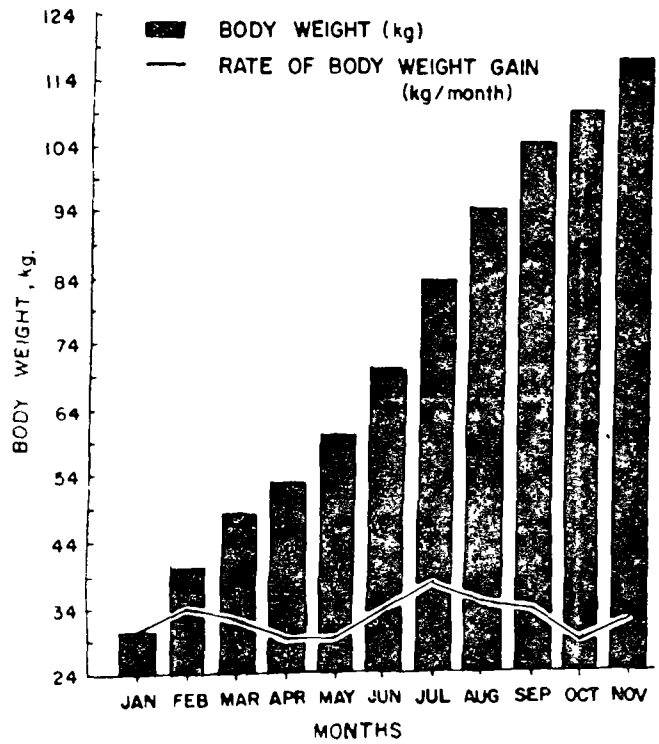

Fig. 6. Trend of body weight gain of calves of Tharparkar cows on managed rangland.

Table 12. Measures of economic viability of Tharparkar herd at Chandan

Attributes*	Discounting rates				
	10%	14%	20%	30%	40%
NPV (Rs.)	13188.00	9163.00	4738.00	212.00	—2221
DB-CR (Ratio)	1.30:1	1.24:1	1.14:1	0.08:1	0.89:1
Annuity	3028.94	2356.74	1424.96	80.24	—1024.92
IRR (%)	—	—	—	30.87	—
PBP	5th year				

*NPV = Net present value in Rs., DB-CR = Discounted benefits — cost Ratios.
A = Annuity in Rs., and IRR = Internal Rate of return in percentage.

T_4 = Grazing during first fortnight of September, November, January, March, May and July.

T_5 = Grazing during second fortnight of September, November, January, March, May and July.

The year was divided into six bimonthly intervals starting from August. Period A, August and September, period 'B' October and November, period 'C' December and January, period 'D' February and March, period 'E' April and May, period 'F' June and July. Grazing could not be carried out in both the years from mid of May to end of July.

The growth of ram lambs was not affected significantly by pastoral treatments (Mertia, 1984a). The seasonality in availability of forage rangelands significantly affected the growth rate. The growth rate of ram lambs was highest during October-November (Table 13). It indicated decline from December onwards.

Table 13. Gains (kg) in body weight per lamb under pastoral treatments in different seasons and years.

Growth (kg) during different seasons	Pastorl treatments			
	Continuous grazing		Deferred rotational grazing	
	1978-79	1979-80	1978-79	1979-80
A Aug.—Sept.	2.80	2.03	1.61	3.09
B Oct. —Nov.	3 42	2.25	3.55	1.90
C Dec.—Jan.	0.05	0.40	0.30	—0.22
D Feb.—March	—0 64	—3.56	—0.80	—3.78
E May—June	—0.22	—1.47	—0.05	—1.59
Total	5.41	—0 35	4.61	—0.60
SEM ±	±0.27	±0.37	±0.25	±0.38
C D at 5%	0.79	1.05	0.71	1.09
C.D at 1%	1.05	1.40	0.94	1.46

The results of this study are conciding to the earlier findings of Ahuja (1970) who reported body weight gains of 8.39 kg/lamb of Jaisalmer breed with yearling ram lambs over a period of 7 months, Sapre (1963) reported average gain in body weight between a yearling lamb and a mature ram lamb of Chokla breed as 10.1 kg under fairly high level of nutrition under farm conditions. Similarly Chakravarty and Das (1964, reported an increase of 6.3 kg per lamb of Marwari breed over a period of 7 months.

The impact of different systems of grazing on the range revealed that per cent basal cover of *L. sindicus* declined over the years under the continuous grazing treatment (T_1) and increased under all the rotational grazing treatment except T_5, where it remained constant (Table 14). Continuous grazing adversely affected the major

Table : 14. Change in the percent cover of six g-ass species in three years (1978-1981) under different grazing system (Mertia, 1984)

Species	Percent cover in different treatments									
	Continuous grazing		Deferred rotational grazing							
	T_1		T_2		T_3		T_4		T_5	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	inal
Lasiurus sindicus	1.37	0.90	0.50	1.64	0.83	0.91	1.50	2.80	0.02	0 02
Eleusine compressa	0.18	0.30	0 05	0.21	0.01	0.12	0.08	0.29	0.72	0.75
Dactyloctenium sindicum	0.11	0.03	0.02	0.03	—	—	—	—	0.02	0.02
Aristida funniculata	0.06	0.02	0.13	0.01	0.14	0.14	0.00	0.01	0.37	0.07
Cenchrus biflorus	0.28	0.19	0.24	0.01	0.21	0.55	0 55	0.12	0.33	0.08
Indigofera cordifolia	0.31	0.01	0.75	0.07	0.00	0.11	0.11	0 02	0.39	0.00
			SEm for treatment ± 0.4011							
			'F' test		H.S					
			C.D. at 5%		0.1112					

H.S. = Highly significant.

grass, i.e. *L. sindicus*. Rotational grazing on range paddocks provided rest period to the grass species to recover. This favoured good growth and maintained desirable composition of major grasses. The major grasses of the arid tract, i.e. *L. sindicus* and *E compressa* are very hardy and survive under the impact of grazing pressure. Once these grasslands are allowed a rest period, they regenerate by self seeding and assume normal vigour and cover. Rotational grazing which allows this rest period favours the growth and preponderance of *L. sindicus* and *E. compressa* (Mertia, 1984b).

At Lawan

Seasgnal grazing cattle

A poor condition class rangeland (Bhimaya and Ahuja, 1969) represented by *Aristida-Cenchrus biflorus-Tribulus community* was put to grazing by cattle. The grazing studies were conducted during 1970 to 1977. The rangeland under study comprised of an area of 60 ha and was divided into four equal paddocks of 15 ha each. Fifteen heifers of Tharparkar breed (with nearly equal body weight and girth) were selected for grazing. The year was divided into four seasons of three months each and heifers grazed in each seasonal grazing paddock. The grazing schedule during each year was monsoon (T_1) August to October, winter (T_2) November to January, spring (T_3) February to April and summer (T_4) May to July.

Maximum body weight gains in the yearling heifers under seasonal grazing was observed in T_1, i e. 31.56 kg/ha based on five years performance and it is followed by T_3, i.e. 13.0 kg/ha and 12.12 kg/ha under T_2 and least 0.1 kg/ha under T_4 summer season (Table 15).

The growth rate of heifers was maximum in T_1 August to October. There was significant variation in the growth rate of heifers under four seasons. The maximum gain under T_1 was due to green and nutritive grasses on the range. There was increasing trend in body weight of heifers upto season T_3 and in exceptional years of high rainfall (1975 and 1976) the increase in body weight had also been observed in T_4. Normally there had been a constant trend of decrease in weight under T_4.

Table 15. Body weight gain (kg) under four pastoral treatment during three years (1975 to 1977).

Seasons	1975-76	1976-77	1977-78	Mean	
T_1	31.13	44.20	27.53	34.29	
T_2	24.00	13.00	2.70	13.27	SEm ±1.05
T_3	13.00	27.87	10.30	17.06	C.D. at 5% 2.91
T_4	12.63	13.27	—1.00	8.30	
Mean	20.19	24.58	9.88		
		SEm ± 0.91			
		C.D. at 5% 2.52			

The study reveals that compartment subjected grazing during summer has least carrying capacity (Table 16), losses in body weight of animals during summer was due to poor quality of forage, high temperature and hot winds.

Table 16. Dry forage yield (kg/ha) in three years (1975-1977) during different seasons

Year	Seasons				Mean			
	T1	T2	T3	T4				
1975	18.767	19.164	17.041	12.903	16.969			
1976	16.410	12.984	9.915	6.045	11.338	SEm ±	C.D. at 5%	C D. at 1%
1977	6.678	9.402	4 726	2.736	5.885			
Mean	13.952	13.850	10.561	7.228				
SEm	± 0.4297							
C.D. at 5%	1.2237							
1%	1.6344							

The dominant grass *Lasiurus sindicus* increased in successive years. Its contribution in the initial year was 1.1 to 4.4 per cent in different grazing paddocks which increased to 77.7 per cent in the year 1977.

There was a progressive change in plant successional trend in all the grazing paddocks. The pioneer species, viz. *Oropetium thomaeum, Traqus b'florus, Eragrostis ciliaris* and *Aristida funiculata* which represented shallow gravelly soils in initial stage which in due course of succession has been replaced by *Eleusine compressa. Dactyloctenium sindicum* and *Lasiurus sindicus* which are invariably more productive and so desirable.

At lawan area

Continuous grazing v/s stall feeding

Studies were conducted on *Lasiurus-Eleusine Aristida* type rangeland during period 1979 to 1983. The grazing schedule during each year was :

T_1 = Continuous controlled grazing on yearlong basis.

T_2 = Continuous controlled grazing and stall feeding @ 4 kg/hay/heifer/day from 1st December to end of July each year.

Harvesting of grass at preflowering stage for conservation as hay for stall feeding assumes importance in this region. Such a management practice may be helpful particularly in case of growing animals which are, by and large, not fed on concentrate feeds.

Result of the four years (1979 to 1983) study revealed that the treatment involving partial conservation of hay from the grazing paddocks and feeding in the lean period was advantageous over the no stall feeding treatment. The advantage of stall

feeding was mainly observed during the lean period (January to July), because the early cut hay contains higher crude protein than the natural stand of the mature grass in paddock. Out of the four years of the study a net advantage of 13 kg/heifer (+5.0 -(8.0)) and 16 8 kg/heifer (+12.0-(4 8)) was observed in 1981-82 and 1982-83, respectively (Table 17). During 1979-80 and 1980-81 continuous gains in body weights were observed in both the treatments. This may be attributed to the availability of more forage due to higher and well distributed rainfall during these years (Mauria *et al.*, 1984) have also observed similar results on rangeland dominated by *Cenchrus* spp. in semiarid region of Rajasthan.

Table 17. Gain in body weight (kg/heifer) under different grazing treatments (1979–1983)

Years	Treatments	Increase/decrease of body weight (kg/heifer)		Net weight (kg heifer)	Dry forage yield (q/ha)
		Growing season (Aug. to Dec.)	Lean season (Jan. to July)		
1979–80	T 1 (No stall feeding)	27.0	+ 5.0	32.0	3.5
	T 2 (Stall feeding)	24.0	+ 3.0	27.0	6.9
1980–81	T 1	26.4	+ 2 2	28.6	7.01
	T 2	28.5	+ 3.1	31.9	11.72
1981-82	T 1	22.0	— 8.0	14.0	2.5
	T 2	27.7	+ 5.0	32.7	3.8
1982-83	T 1	24.0	— 4.8	19.2	1.7
	T 2	23.5	+ 12.0	35.5	3.5

Effect of two grazing management practices had significant effect on forage production of key grasses and legume species. Continuous grazing had adverse effect on forage production but partial harvesting affected favourably (Tables 18 and 19). The per cent relative cover of key species was affected adversely in T-1 indicating considerable decline where as partial harvesting T-2 indicated considerable increase in percent cover of *L. sindicus* (Mertia, 1986 b).

Table 18. Relative dry forage contribution (%)

	T1		T2	
	Initial year 1979-80	Final year 1982–83	Initial year 1979-80	Final year 1982–83
Lasiurus sindicus	75.53	58.78	76.6	83.26
Eleusine compressa	3.98	2.02	0.12	0.84
Cenchrus biflorus	3.02	2.02	0.57	4.78
Aristida funiculata	0.52	1.6	0.77	1.85
Indigofera cordifolia	11.66	0.14	14.3	0.92

Table 19. Dry forage yield (kg/ha) of key species under different treatments (1978-1982)

Species	T1					T2				
	1978	1979	1980	1981	1982	1978	1979	1980	1981	1982
Lasiurus sindicas	1.775	1.081	1.696	0.255	0.292	2.599	2.016	2.938	0.762	0 818
Eleusine compressa	0.086	0.085	0.076	0.090	0.00	0.004	0.007	0.026	0.018	0.009
Dactyloctenium sindicum	0.004	0.015	0.00	0.00	0.125	0.008	0.003	0.002	0.00	0.088
Cenchrus biflorus	0.066	0.00	0.165	0.163	0.010	0.009	0.00	0.183	0.169	0.053
Indigofera cordifolia	0.246	0.005	0.117	0.038	0.002	0.448	0.025	0.106	0.087	0.009
Aristida funniculata	0 001	0.005	0.012	0.107	0.008	0.004	0.00	0.106	0.004	0.020

	SEm±	C.D. at 5%	C.D. at 1%
Year	0.0335	0.0929	0.1221
Treatment	0.0212	0.0587	0.0772
Species	0.0367	0.1017	0.1337

It can, therefore, be concluded that hay conservation at preflowering stage from half of the portion of grazing paddocks for stall feeding should, therefore, restored for better livestock and rangeland maintenance as compared to that in continuous controlled grazing.

Grazing systems and secondary production

Grazing based on carrying capacity appeared to be most advantageous both, in tetn.s of the primary and the secondary production as compared to the medium or the high intensity of grazing. Higher body weight gains have been observed under light intensity (2.4 ha/heifer) of grazing as compared to the moderate (1.2 ha/heifer) and the heavy intensity of grazing (0.6 ha/heifer), i.e. 6.8, 5.4 and 4.4 kg/animal/month under control, moderate and heavy intensity of grazing, respectively.

Results revealed that stocking rate of 4 ha/heifer was capable of giving 200-279.7 g/day/heifer body weight gains in early stage of range development. The increased stocking rate of 2.5 ha/heifer has given body weight gain of 178-243.8 g/day/heifer which is fairly high on *Lasiurus-Eleusine* rangeland in arid conditions having average precipitation less than 250 mm.

Stocking rate of 0.56 ha/ram lamb resulted in the body weight gains of 39 g/day/lamb on yearlong basis.

Fig. 7. Sewan grassland range showing proper use by livestock.

Considering different systems of grazing, both heifer as well as sheep, there was no significant difference between continuous controlled grazing and deferred rotational grazing. However, distinct advantage of deferred rotational grazing for better establishment of perennial grasses through natural self seeding is obvious, specially in areas where reseeding has been practised.

On an average, body weight gain of heifer was 200 to 279.7 g/day. The maximum body weight gains of 406 g/day/heifer were achieved from August to October. Similarly in ram lambs 39 g/day/ram lamb could be achieved on well managed rangelands. In a recent study it was noted that heifers are capable of producing 50 to 300 per cent more body weight on *Lasiurus:Eleusine* rangeland during July to December as compared to animals maintained by the local villagers. It has also been found that in range management area, heifers take 2.5 to 3.5 years for first calving as against 4 to 5 years by the flocked local villagers.

The maximum milk production of first lactation varied considerably from 4.8 litres/day/cow in animals on managed rangelands as compared to 2.33 litres/day/cow in local animals of same breed and age.

Studies on seasonal grazing of rangelands revealed that the growth of animals was highest (31.56 kg/ha) during August to October based on a five years performance. There was no significant difference in the growth under the season T_2 October to December and season T_3 January to March, i.e. 12.12 and 13.0 kg/ha respectively. Decrease is the body weights from April to June was due to the low carrying capacity of the rangelands.

Comparative growth of heifers and lambs under mixed grazing revealed that growth of heifers per unit area was highest 23.51 kg/ha when grazed alone (T_1). The lambs also gained maximum body weight gains when grazed alone in T_2. For increased primary and secondary productivity it is beneficial to carry alternate grazing with cattle and sheep.

Partial conservation as hay and feeding it to animals during the lean period has led to the higher gain in body weight as compared to continuous controlled grazing. Out of the four years of the study a net advantage of 13 kg/heifer (+5.0—(8.00) and 16.8 kg/heifer (+12.0—(4.8)) was observed in 1981-82 and 1982-83, respectively.

RECOMMENDATIONS

1. Based on the land use pattern in this district, it is evident that animal husbandry is economical and ecologically successful. To meet out the imbalance between demand and supply of fodder, the sewan seems to be most promising grass species for sustained fodder supply in this region (Fig. 7).
2. State Government in the arid region should adopt the policy of range management and development based on land condition and forage potential.
3. Programme needs implementation in this region to :
   (a) stop further deterioration of these rangelands,
   (b) reclamation of the degraded rangelands to increase their production potential, and
   (c) introduce system for efficient utilization and stabilization of production potential.
4. It needs adequate participation of local pastoral community, panchayats, developmental agencies to understand, adopt and implement improved techniques in fields.
5. Government should explore all possibilities to stop overstocking and migration of livestocks to other parts of the country.
6. Now, with the inception of Indira Gandhi Nahar Project, there is hope for getting water for irrigation on left bank of Canal. The efficient use of water would be to encourage private farmers beside Government agencies for irrigating natural sewan pastures to meet out fodder requirement of this region.

RESEARCH NEEDS

Research achievements in the field of range management in relation to development and efficient utilization of rangelands and increased primary and secondary productivity in arid regions, are encouraging. The following important aspects need immediate attention.

1. Introduction of exotic and indigenous trees to supplement grass production. More emphasis is required to assess performance of *Prosopis cineraria*, an important fodder and fuel tree of the region. Since it does not affect the crop grown in association with it and also when fully grown, can provide 58 to 60 kg dry leaves per tree.
2. There is also a need for studies on supplemental feeding in grazing experiments of agro-industrial by-products, i.e. urea, molasses and beat pulp in the livestock feeding systems.
3. Long term grazing studies on rangelands are required so that economics of the primary productivity could be linked with the secondary productivity calf and milk production. The study under progress at Chandan on the productivity in totality need to be undertaken at more sites to provide more useful data on maturity, conceivement and lactation period for sound recommendation.
4. Study on goats, which has the largest population in this region need to be intensified.
5. Preliminary studies on trial of perennial legumes has not given encouraging results in this region. There is need to study the performance of local legume, *Cyamopsis tetragonoloba* 'Guar' in rangelands to maintain secondary productivity of growing and milking stocks during lean period from January to June.
6. To examine utility of forage conservation measures in enhancing the productivity of animals on rangelands during lean period, study on stall feeding from hay are already underway but needs critical examination to check deterioration in forage quality.
7. Stock drinking water facilities are lacking in the larger part of this district and at many places water available is brackish. The lack of water lead to under utilizati on of grass cover in northern and western border areas of this district and forces livestock breeders to resort to migration.
8. Introduction and evaluation of top feed trees and shrub species need attention which can supplement the fodder requirement during lean periods.

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APPENDIX - I

LIST OF COMMON PLANTS OF ARID RANGELANDS

Botanical name	*Common name*
Perennial Grasses	
Lasiurus sindicus Henr.	Sewan
Cenchrus ciliaris Linn.	Dhaman
Cenchrus setigerus D. Don.	Anjan
Panicum antidotale Retz.	Graman
Dichanthium annulatum (Forsk.) Stapf.	Karad
Cyperus conglomeratus Rottb.	Nagar Moth
Cyperus arenarium Retz.	Moth
Cymbopogon jwarancusa (Jones) Schutt.	Boor
Dactyloctenium aegyptium (Linn.) P. Beauv.	.Ganthiya
Eleusine compressa (Forsk.) Aschers & Schweinf. ex Christensen (syn. *E. flagellifera* Nees)	Tantiya
Eragrostis diarrhena (Schult.) Steud.	Khyahi
Panicum turgidum Forssk.	Murat
Annual Grasses	
Aristida funiculata Trin. et Rupr.	Lamp
Aristida adscensisnis Linn.	Lamp
Aristida hirtigluma Steud ex Trin et Rupr.	Dholio lamp
Aristida pogonoptilla (Janb. et Spach.) Boiss.	Dholio lamp
Brachiaris ramosa (Linn.) Stapf.	Kuri
Cenchrus biflorus Roxb.	Bhurat
Cenchrus prieurii (Kunth.) Maire	Lamba bhurat
Chloris virgata SW.	Chimki
Eragrostis unioleides (Retz.) Ness	Under pancho
Erogrostis tremula (Lamk.) Hochst. ex steud.	Chirighas
Oropetium thomaeum (Linn.F.) Trin.	Khargos chunti
Legumes	
Indigofera astragallina DC.	Baker
Indigofera anneaphylla Linn.	Adio bakeriyo
Indigofera cordifolia Heyne ex Roth	Bakaria
Indigofera linifolia Retz.	Lambio bakerio
Indigofera linnaei Tli	Bakorio

Phaseolus trilobus Ait	Chiri moth
Rhynchosia minima (Linn.) DC.	Topani bel
Rhynchosia pulverculenta Stocks	
Tephrosia purpurea (Linn.) Pers.	Bisani
Tephrosia falciformis Ramaswami	Bisani
Tephrosia strigosa (Dalz.) Santapau & Maheshwari	Bisani

Edible Herbs and Shrubs

Boerheaavia elegans Choisy	Sati
Blepharis indica T. Anders	Bhangari
Citrullus colocynthis (Linn.) Schard.	Tumba
Cleome brachycarpa Vahl.	Noli
Corchorus depressus (Linn.) Christenson	Chamkash
Crorchorus tridens Linn.	Kagleritoru
Cucumis prophetarum Linn.	Khat kachre
Convolvulus microphyllus Seib. ex Spreng	Dholi phooli
Crotalaria burhia Buch. Ham ex Benth.	Sinya
Fagonia cretica Linn.	Dhamaso
Gisekia pharnaeoides Linn.	Morangio
Glossonema variance (Stocks) Benth. ex Hook. F.	Dhoodha
Heliotropium marifolium Koen ex Retz.	Choti santari
Heliotropium supinum Linn.	Kali bui
Limeum indicum Stocks ex T. Anderson	
Mimosa hamata Wild	Jinjani
Neurada procumbens Linn.	Chhapari
Polygala erioptera DC.	Bayasan
Sericostema pauciflorum Stocks	Khir khimp

APPENDIX-II

LIST OF COMMON FODDER TREES

Botanical name	*Common name*	*Palatability*
Acacia senegal (Linn.) Willd.	Kumat	Moderate
Acacia nilotica (Linn.) Del. subsp. *indica* (Benth.) Brenam (syn. *A. arabica* auct. non Lamk)	Desi babool	Good
Azadirachta indica A. Juss.	Neem	Good
Capparis decidua (Forsk.) Edgew.	Ker	Fair
Maytenus emarginata	Kankera	Fair
Prosopis cineraria (Linn.) Mac Bride (syn. *P. spicigera* Linn.)	Khejri	Good
Prosopis juliflora (SW) DC.	Bilayati babool	Fair
Salvadora oleoides Decne.	Pilu	Good
Salvadora persica Linn.	Khari Jal	Good
Tecomella undulata (Sm. Seem.)	Rohida	Fair
Ziziphus mauritiana Lamk. (syn. *Z. jujuba* Lamk.)	Bordi	Good
Ziziphus nummularia (Burm f.) Wight & Aron.	Jhadki	Good

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