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RANGE MANAGEMENT, UTILISATION AND PRODUCTION IN ARID ZONE

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The paper deals with problems of arid zone under agroclimatic conditions not suitable for stable agriculture. In places like Jaisalmer, about 5% land is under cultivation and rest is under grazing. In order to improve local economy, it is essential to upgrade the existing rangelands (which have denuded due to overgrazing stress) to improve the economy of the tract. Emphasis is laid on adequate protection, grubbing of unwanted bushes, stabilisation of sand dunes, forage production, reseeding techniques with suitable grass species under different agroclimatic regions of the desert, methods of utilization of rangelands, carrying capacity of different condition class of ranges, livestock production in relation to range management and grazing practices, grazing behaviour and preference palatability of different species by different kinds of livestock, supplemental feeding, housing, and drinking water requirements of animals on the range.

INTRODUCTION

Out of the total land area of 3.2 million sq. km of this country, about one-third falls under arid and semiarid zone. The arid regions are spread out from Leh and Ladakh in the extreme north, north-western areas, to Cape Comorin in the extreme south. There are three distinct zones, namely, Northern Cold Desert, North Western Hot Desert, and Southern Hot Tropical Zone. The total area of arid and semiarid zones in India works out to 312,490 and 949,600 sq. km respectively. The percentage of areas under arid zones in states of Rajasthan, Gujarat, Punjab & Haryana (combined), Andhra Pradesh and Mysore is 63, 20, 9, 7 and 1% respectively.

PROBLEMS

On an average, the aridity index is 78 in North West India (with 91 in Jaisalmer), 68 in Peninsular India, and 88 in cold desert of Ladakh (Krishnan, 1968).

Climate in north-west arid zone is characterised by extreme temperature ranging from below zero in winter to above 50° C in summer, with precarious and erratic rainfall varying from 100 to 500 mm annually. About 90% of rainfall occurs from July to September. Hot dry winds and dust storms from southwest and west are a common feature.

About 40% of the area is put under cultivation and in places like Jaisalmer District only 5% area is cultivated. Rest of the area is mostly grazed.

Due to very erratic rainfall conditions, agriculture is mostly unstable in this region. Therefore, pasture development for livestock raising has a very important role to play in the economy of this tract.

Native pastures have deteriorated to the last stage of degradation due to heavy pressure of local livestock population.

Livestock population in arid and semiarid districts of Rajasthan, Haryana and Gujarat States (North-west region of India) is 21.41 millions, of which cattle, buffaloes, sheep, goats, camels and others comprise of 7.35, 2.36, 6.55, 4.23, 0.65 and 0.27 millions respectively. These when converted to adult cattle units, amount to 10.58 millions. Livestock of this tract is reputed for hardiness and inherent high production potentials.

Available forage from farming, cultivable waste, fallows, pasture lands is about 63.3% of the needs of existing livestock under normal years of rainfall. The production is very much lower during the years with subnormal rainfall leading to acute scarcity conditions resulting in alarming problem. This entails transport of fodder from other states to keep the livestock living, and taxes the State and Centre exchequer very much (Ahuja & Muthana, 1969). In addition to that the livestock is forced to migrate to other states where they get crossed with local mongrels resulting in loss of breed entity, contacting of diseases which cause economic losses, reduction in livestock production potentials, reduced employment to local people, less availability of nutritive feeds like milk and meat to local population, and devoiding of animal excreta to soils in this tract, etc.

Grassland Covers in Arid Zone

Grassland cover of north western parts of arid regions of India has been recognised as *Lasiurus-Cenchrus-Dichanthium* type (Dabadghao, 1960). From a reconnaissance survey of about 11,000 sq. km in Luni Basin of Western Rajasthan, Satyanarayana (1963) reported twelve pasture types within this cover. The grasslands in this region are very heterogenous in nature occurring on vast barren sandy areas, rocky stretches, highly saline areas and areas with climax vegetation where there is practically no grazing due to water scarcity (Ahuja & Bhimaya, 1966).

Pasture Types and Evaluation

Various methods to evaluate different grassland types have been discussed by Bhimaya and Ahuja (1968). They conclude that forage estimation, botanical composition through Parker's loop method and stock (vegetational) maps help to assess range productivity. Criteria for determining five condition classes of different rangelands have been described by Bhimaya & Ahuja (1969). These aid to determine carrying capacity of different pastures.

About 80–90% of grasslands in arid and semiarid regions is under 'Poor' to 'Very Poor' conditions and is subject to severe erosion hazzards; while that under climax vegetative cover is not grazed due to water scarcity (Ahuja, 1969*a*, *b*).

Certain aspects of water use, plant ecology, range management and utilization to improve the economy of this tract are summarised below.

(i) *Selection of sites*

Lands falling under class V to class VIII are unfit for crop cultivation and those under class IV are subject to wind erosion and water erosion hazards. It will be desirable to take up pasture development work with the start in such class of lands, in areas with easy accessibility and water facility so that local people can visit the places frequently and realize the value of such development work. It will be desirable if long term grass-

crop rotation is followed on class IV lands to reduce erosion hazards, improve soil fertility and vegetative production.

(ii) *Fencing*

In this part of the country no development project involving land can be successful without proper fencing with a view to save it from heavy livestock pressure. Amongst various types of fencings tried and studied, it has been found that angle iron posts with barbed wire fencing are by far the most effective and economical in the long run (Bhimaya, *et al.*, 1966). As iron and steel material is not easily available trench and core wall fencing, corewall thorn fencing, live-hedge fencing may be constructed on co-operative or 'Shramdan basis' by villagers, during forced idle period or lean periods. Such types of fencings need regular care and repairs.

Cost of angle iron post and barbed wire fencing is Rs 4.00 per running metre Smaller the sizes of block, greater is the proportionate cost per hectare. The cost of fencing per hectare in blocks of 40, 80, 200, 400 works out to Rs. 200, 150, 75 and 50 respectively (Ahuja, 1969).

(iii) *Grubbing of unwanted bushes*

Unwanted thorny bushes like *Lycium barbetum*, *Belanites aegyptica*, *Acacia leukophloea*, *Mimmosa hemata*, etc., which hinder the growth of grass species and are troublesome to grazing animals; should be grubbed out mechanically followed by application of herbicide 2-4-5-T (trichlorophenoxyacetic acid) immediately after cutting away aerial parts of bushes (Dabadghao, 1960 in' Ref').

(iv) *Role of top feed cum shade trees of grasslands*

On a 'Good' grassland, there should be per hectare about 30 useful tree species like *Prosopis cineraria, Azadirachta indica, Salvadora* sp., *Albizzia lebbek, Acacia nilotica*, etc., suiting different tracts, to provide shade, top feed during lean periods of the year, and timber and fuel (Bhimaya and Ahuja, 1966). Bushes like *Zizyphus nummularia* (Bordi) should not have more than 14% crown cover in a rangeland. In areas under shifting and semi shifting sand dunes, *Acacia tortilis* have given good performance. In saline areas, species like *Tamarix articulata, Prosopis juliflora, Acacia nilotica* var. *indica* have performed well. Protein content of leaves of top feed species is very high i.e. 10 to 29% (Ganguley *et al.*, 1964), and these top feed species provide good nutritive material during lean periods of the year (Ahuja *et al.*, 1968).

(v) *Soil conservation*

On lands with shallow soils and rolling topography with about 2 per cent slope, contour furrows with 929 sq cm (1 sq. ft) cross-section spaced 8 to 10 m apart show four-fold increase in the forage yield during 3-4 years (Bhimaya and Ahuja, 1967). In case of lands at foothills, flowing nallas should be harnessed with pucca masonry dam and earthen bunds, across the slope to serve as 'water spreading devices'. Gulley and nalla plugging should be carried out on rangelands. Cost of such soil conservation measures is about Rs. 100/ha.

(vi) *Stabilisation of sand dunes*

In arid zone, shifting sand dunes are very active, except during monsoons. They threaten the existence of nearby villages, towns and fertile lands. If stabilised and managed properly they offer a potential productive site for afforestation and grassland development (Kaul, 1968). For stabilisation and rehabilitation of sand dunes, three distinct processes are involved, namely, (a) protection against biotic influence, (b) treatment of shifting sand dunes by fixing barriers (mulching) from the crest down to the heel of dune across the wind direction, (c)(i) afforestation by direct sowings and or plantings of suitable tree species and, (ii) seeding or planting root slips of drought hardy perennial tussecky grass species. In such areas till dunes are stabilised grazing should not be allowed. Grass may be harvested manually.

(vii) *Forage production*

An efficient grassland management aims at maximum utilization of forage without undue interference with the growth and vigour of the important fodder species.

With adequate fencing and grazing the rangeland according to their carrying capacity (aiming at 70% forage utilization level), the forage yield can be doubled within three years time (Ahuja, 1969 *a*, *b*).

Estimated air dried forage production on protected 'Very poor', 'Fair', 'Good' and 'Excellent' grasslands is 200, 500, 750, 1,000 and 1,500 kg/ha during normal years of rainfall (Bhimaya & Ahuja, 1969). The yields fluctuate with the rainfall.

(viii) *Suitable grasses for reseeding*

Natural succession of superior species of grasses in arid and semiarid regions is a time-consuming process. Hence reseeding with suitable high forage-producing species suiting different agroclimatic tracts is the only solution.

(*a*) *Selection of suitable species for reseeding in different tracts*—Perennial grass species like *Cenchrus ciliaris, C. setigerus, Lasiurus sindicus, Dichanthium annulatum, Panicum antidotale, Sehima nervosum,* are grouped as 'High perennial' species as they give high forage yield under natural rainfed conditions. *Dichanthium annulatum* gives high yields on heavy soils with annual rainfall above 380 mm. *Cenchrus ciliaris* and *C. setigerus* produce high forage on well drained soils under medium to low rainfall. *Lasiurus sindicus* gives high forage yield on sandy soils with low precipitation. *Panicum antidotale* performs well on well-textured soils with annual rainfall of 250 mm and above, under protected conditions; while *Sehima nervosum* yields good forage on hilly terrain.

(*b*) *Reseeding*—This involves proper soil working, sowing of appropriate grass species and the after care of the resultant cover. The soil working and grubbing of unwanted species should be as thorough as is done for normal agricultural crop, and should be completed by end of June. Due to erratic rainfall conditions, and poor germination of seeds of *Lasiurus sindicus* and *Dichanthium annulatum* (Ahuja & Bhimaya, 1967), sowing of mixture of seeds *Cenchrus* species and *Dichanthium annulatum;* and *Cenchrus* species and *Lasiurus sindicus* are recommended for high and low rainfall tracts respectively (Ahuja & Bhimaya, 1966). The seed rate of different mixtures is 5 to 7kg/ha. Seeds suiting the tract should be drilled uniformly in lines 75 cm apart, immediately after the first effective showers, in 8 to 10 cm furrows, at depth of not more

than 2 to 3 cm under the soil. Germination of pelletted seeds of *Lasiurus sindicus* is reported to be higher (Chakravarty & Bhati, 1969).

In view of erratic rainfall and fairly high cost involved in reseeding, it is advisable to resort to root slip planting of grasses like *Lasiurus sindicus* and *Dichanthium annulatum* and nurseries established for the purpose (Ahuja & Bhimaya, 1967). Verma and Chakravarty (1969) found better establishment in *Lasiurus sindicus* pasture by planting seedlings in comparison to rooted slips. But due to water scarcity conditions, presently, the use of rooted slips is recommended.

Such reseeded pastures need at least two weedings during their first year of establishment. It is advisable not to graze such reseeded pastures during first year.

(*c*) In highly saline soils where other good species fail to come up, a lower perennial grass like *Sporobolus glaucifolious* performs well. It is quite nutritive and has high forage production potentials (Ahuja & Bhimaya, 1966).

(*d*) The grazing capacity of these reseeded pastures is very high. Yields of air dried forage from pastures of *Dichanthium annulatum, Cenchrus species* and *Lasiurus sindicus* of 8.9, 4.7, and 3.6 tonnes/ha respectively, have been recorded; under rainfed conditions. *Sporobolus glaucifolious* has recorded yield of 1.5 to 2 tonnes/ha. (Ahuja, 1969).

(*e*) *Fertilization*—Application of sulphate of Ammonia at 113 kg/ha (20lb N/ acre) has resulted in increased yields of forage by 50 to 70% over their respective controls. The protein content of forage on fertilised pasture was higher than that in control plots.

(*f*) *Reseeded pastures and areas with climax vegetation*—The estimated cost of upgrading the land under denuded stage for pasture establishment through fencing, reseeding provision, of stock water etc. (based on 1000 ha./blocks), is Rs 400/ha. (Ahuja & Muthana, 1969).

After the rangeland is established with climax vegetation, as a result of reseeding, it is advisable to divide the entire area into four compartments. Forage from one of the compartments should be harvested every year by rotation, and preserved as hay. Grazing may be carried out in rest of the three compartments by rotation, depending upon the carrying capacity of the pastures.

Extensive areas in the low rainfall region of Jaisalmer, Bikaner and Barmer districts are covered by the high-producing nutritive grasses like *Lasiurus sindicus.* But these pastures are fast deteriorating due to indiscriminate overgrazing. Such vast areas cannot be protected in a short time. In order to upgrade these areas, it would be desirable to bring them under the purview of the 'State Forest Act' or the 'State Soil Conservation Act'. Then regulated grazing could be executed by dividing the area into suitable blocks and practising rotational grazing.

Hilly areas—In hilly tracts and at the foothills reseeding is generally not a practical proposition. Controlled grazing on the basis of the optimum grazing capacity is the best way of upgrading such grasslands.

(*ix*) *Rodent control*

Some vertebrate pests, viz. rodents like gerbils, cause heavy damage to pastures by gnawing the stems and eating away the rhizomes. They have to be controlled.

Amongst the various poisons tried to kill these rodents pests, baiting with zinc phosphide and compound No. 1080 (monofluoro acetate) have proved to be most efficacious and economical in the long run (Prakash, 1969).

(*x*) *Utilization*

Utilization of forage can be achieved through (*a*) Harvesting, preserving and then feeding to the livestock, and (*b*) Grazing.

(*a*) *Harvesting*—Due to adverse agroclimatic conditions mentioned above, forage yield from existing rangelands is very low. Cost of harvesting, therefore, is exorbitant (Ahuja, 1966). Harvesting time of agricultural crops and forage on the range coincides. This results in increased labour wages specially in low population density areas like arid zones. Hence harvesting of forage on rangelands, on a mass scale, is not a practical proposition.

In reseeded, established and fertilised pastures, forage yield is fairly high, it is best to reserve a portion of it to harvest during flowering stage and preserve it as hay for feeding down calves, milking stock, sucklings, sick animals, working bullocks and all stocks during adverse climatic conditions.

(*b*) *Grazing*—Best way to utilise the native rangelands is through controlled grazing which is dependent upon carrying capacity. Carrying capacity (on year-long basis) of pastures under different condition classes in arid zones during normal years of rainfall is as under:

Condition class of pasture	*Number of adult cattle units* (300 *kg body wt per* 100 ha.)
Excellent	25–30
Good	20
Fair	17
Poor	13
Very poor	6

It saves cost of harvesting low set grasses and low-yielding annual fodder species which are very uneconomical to harvest. Livestock while grazing work up the soils through their hooves, break the top crust of soil, thereby encouraging better percolation of water for plant use and better range production. Their excreta, i.e. dung and urine add to the plant nutrient contents of soil and improve its fertility. Thus the soils are enriched.

Livestock Production in Relation to Range Management

It is essential that these rangelands are properly utilized so that they are permanent asset. Studies at the Central Arid Zone Research Institute, Jodhpur reveal that:

Cattle

With adequate protection to the rangelands, and following grazing at the normal carrying capacity basis, aiming at 70% utilization, highest gains in body weight of adult cows (average body weight 272 kg), were obtained under continuous controlled grazing system, on year-long basis. These gains in body weight of cows under 'Good', 'Fair'

and 'Poor' rangelands averaged to 56.7, 35.5, and 25.8 kg/animal respectively. These gains were highest during monsoons (July-October) and were of the order of 32.7, 34.5 and 24.0 kg/animal under 'Good', 'Fair' and 'Poor' rangelands respectively. Lactating cows grazing on rangelands, yielding about three litres of milk per day in the pail, did not need concentrates during this period. Lactating cows from whom milk was not drawn for human consumption, nursed their young ones satisfactorily, without receiving supplementary feeds, even during the lean periods of the year (Ahuja & Bhimaya, 1967). Livestock production declines from November onwards and it is more severe from January onwards due to poor nutritive value of dried and weathered forage. In order to have proper production it is essential to provide concentrate rations from November to June (Ahuja, 1969).

Growing stocks, i.e. yearling heifers (having about 90 kg body weight) also attained maximum growth under continuous controlled grazing systems. These gains in body weight per heifers averaged to 64.4, 67.9 and 45.4 kg in 'Poor', 'Fair' and 'Good' condition class rangelands, respectively, on yearlong basis. As 'Good' range could carry more number of animals, net gains were highest in this rangeland. Total gains in body wt of heifers on a unit area of 100 ha. of range of 'Good', 'Fair', and 'Poor' condition were 1892, 1656 and 1055 kg respectively. Growth rate is highest during monsoon season (July-Oct.), irrespective of breed of cattle and condition class of rangeland. The growth rate thereafter shows a decline due to stress of weather, and mature and dry condition of the forage possessing low nutritive value. In order to have optimum production in growth of growing stocks, it is essential to provide concentrates from December-June (Ahuja *et al.*, 1970).

As the availability of area of rangelands is very much lower than that needed to maintain available livestock (Ahuja, 1969), studies conducted on growth of yearling heifers under different intensities of grazing stress on the rangeland viz —(a) Light intensity (i.e. as based on carrying capacity), T_1, (b) Heavy intensity (i.e. four times the stress as compared to that based on carrying capacity basis), T_2, (c) Medium intensity (i.e. double the stress as compared to that on carrying capacity basis), T_3, (d) Heavy intensity plus concentrates feeding from 16th December to 30th June), T_4, and (e) Medium intensity plus concentrates feeding from 16th December-30th June), T_5— revealed that (i) Growth on year-long basis per yearling Tharparkar heifer on *Lasiurus sindicus-Aristida* pasture (with annual rainfall 240 mm) was 70.2, 31.9, 46.6, 94.8 and 121.8 under the above respective treatments, and (ii) that of Konkrej heifers on *Cenchrus-setigerus-Aristida* pasture (with annual rainfall of 526 mm) was 74.0, 63.4, 70.4, 117.7 and 127.3 kg under the above respective treatments. Animals under T_2, T_3, T_4, and T_5 were given dry roughage feeding when it got exhausted on the range experimental plots. Thus amongst the treatments where no concentrates are given, continuous controlled grazing has proved to be better for livestock production. Growth rate is higher by about 70% under T_5 over T_1 (Ahuja *et al.*, 1970 *a, b*). Higher growth is responsible for early reproductive maturity, as some of them evince oestrus. Cost per increase in kg of body weight of heifers under T_1, T_2, T_3, T_4, and T_5 in *Lasiurus sindicus* dry land range works out to Rs. 1.71, 5.05, 2.91, 3.12 and 2.24 respectively. The higher cost of concentrates feeding under T_4 and T_5 will compensate through early maturity which is responsible for higher production in lifetime of animals.

There are indications that in dryland ranges, due to continuous grazing, for a number of years, high yielding and palatable species show a declining trend. Hence preliminary investigation conducted to find out livestock production under continuous controlled grazing versus different systems of deferred rotational grazing revealed that the growth rate of cattle and sheep did not differ significantly between the above mentioned treatments. Growth of yearling heifers on 'Good', 'Fair' and 'Poor' rangelands was 65.8, 67.9 and 39.8 kg heifer respectively under continuous controlled grazing on yearlong basis (Ahuja, 1968).

Sheep

(*a*) *Growth*—Amongst different systems of grazing viz., deferred grazing and continuous controlled grazing systems tried, it was seen that sheep production was highest under continuous controlled grazing and it was least when pasture was deferred to grazing from July to October (Ahuja, 1962). Under continuous controlled grazing on 'good'and 'Fair' rangelands, breeding ewes showed gains in their body weight by 9.2, and 7.1 kg/animal respectively. Adult wethers gained by 7.9 kg/animal on yearlong basis on grazing alone on a 'Poor' range. Most of the gains in body of sheep were exhibited from July-December. Thereafter (Jan-June), animals just maintained their body weights. Breeding ewes lambed during Janaury and February. They showed some losses in their body weights during winter and spring months due to parturition and lactation stress; but the losses were regained during summer months.

Yearling ramlambs showed increases in their body weight by 10.0 and 11.70 kg under continuous controlled grazing system on yearlong basis under 'Fair' and 'Poor' rangelands (Ahuja, 1964).

Growth of yearling ramlambs under different deferred-rotational grazing systems and continuous controlled one was not significantly different. But it did not differ with different breeds. Growth of yearling ramlambs of Chokla, Marwari and Jaisalmeri breed of Sheep was 18.82, 25.81, and 25.91 kg/ animal, on yearlong basis, on an average. Growth rate is highest during July-December.

(b) *Wool Production*—Yield of wool during a year was found to be directly proportional to body weight of sheep. Yield of wool from rams and wethers was higher than that from ewes and yearling. Yield of wool from wether was 2.1 kg. per wether per year while that per breeding ewes in 'Fair' and 'Good' ranges was 1.43, and 0.92 kg on year-long grazing basis (Ahuja, 1962).

Yearling ramlambs of Chokla, Marwari and Jaisalmeri breed of sheep yielded 1.83, 1.86 and 1.54 kg/ animal respectively on year-long basis under controlled grazing system (Ahuja *et al.*, 1967).

Quality of wool production, depends on the breed of sheep. Chokla breed of sheep produce finest wool amongst the breeds of sheep in this tract, while that from Malpura breed is the coarsest (Sule, 1968; Mirajkar & Patil, 1970). Taneja and associates (1969) believe that production of fine wool is controlled by a dominant gene K^L which is responsible for low potassium content in their blood. They further conclude that in a breed of sheep as the frequency of K^L gene increases, the average diameter of wool decreases.

Goats

Goats have been thought to be an alert and destructive animal for forest and ranges. Studies reveal that goat is useful animal in the desertic region (Bose *et al.*, 1965). It serves as foster mother to lambs, cow calves, even calves. Importance of goats in the economy of sheep rearing can not be ignored, specially when they are prolific breeders, produce milk for feeding orphan lambs, mostly of sheep lambing from January onwards, and for mutton kids by utilizing thorny shrubly vegetation; which is not acceptable to cattle and sheep. It is because of this in arid condition in a flock of sheep, proportion of milking goats to breeding sheep varies from 20 to 30%. The coefficient of correlation between ownership of sheep and goats in arid zone is 0.762 (Bose *et al.*, 1965).

Yearling castrated male goats increase in their body weight by 7.2 kg/animal by grazing alone on a 'Good' pasture on year-long basis (Bhimaya *et al.*, 1969), and it accounts to 1800 kg growth in a year on a unit area of 100 hectares of rangeland.

Grazing Behaviour and Preference Palatability

Utilization of different plant species will depend on growing habits and morphological characteristics and chemical composition of plant species and seasons of year suiting different species of farm animals. Amongst all grasses, *Cenchrus ciliaris* and *C. setigerus,* the perennial species are most palatable to all species of farm animals during the entire year. Annual species like *Aristida funiculata, Cenchrus biflorus* cause severe discomfort of sheep from end of August to beginning of November as their awns and burrs pierce through the mouth parts and skin of the grazing animals. Such species are also troublesome to cattle. During this period perennial species like *Dichanthium annulatum* and *Lasiurus sindicus* are relished the most. From November onwards these perennial species become woody, therefore are not liked by cattle and cause discomfort to sheep by injuring their mouth parts with sharpends of stems; and therefore animals whose burrs and awns have shedded are relished. From March onwards when annual grasses get exhausted, high perennials get broken down, are eaten upon. Details have been discussed by Ahuja (1969). During hot weather, animals are crazy after greens. Even cattle eat green shoots of *Calligonum polygonoides*, *Capparis aphyla,* and flowers of *Areua psudotomentosa* which are normally unacceptable to them. *Tribullus terristeris* is poisonous to cattle while it is highly nutritive for sheep. *Fagonia critica* and *Blapheris* sp. are highly palatable to sheep and goats but are non palatable to cattle. Due to thorny nature of plants, species like *Lycium barbatum, Belanites aegyptica* and *Mimosa hemata* are harmful to cattle on the range; but their leaves are eaten up by mostly goats voraciously and to some extent sheep. Low set grasses like *Oropetium thomium* and species of *Eneopogon* can be only grazed upon by sheep. In order to have best utilisation of rangeland production, it is best that sheep and goats follow cattles. Goats will eat up thorny bushes which otherwise are troublesome to cattle (Ahuja, 1969).

Animal Health

Due to inadequate communications in the interior of the desert and high cost of treatment of animals, it is advisable to adopt prophylatic measures to ward off the

attack of diseases as far as possible. It is very essential to carry out preventive inoculations and vaccinations against deadly diseases like Rinder Pest, Haemorrhagic Sapticimia, Black Quarters etc. In case of sheep it is essential to carry out periodic deworming. External parasites like ticks, lice, should be controlled by dipping or spraying periodically. In the arid regions, mineral deficiencies in livestock are very common and these should be controlled by providing mineral mixture in feeds and mineral salt licks. After taking these precautions and providing necessary timely veterinary aid, not only cost of feeding goes down, but the mortality is reduced and livestock returns increased (Ahuja & Bhatia, 1969).

Water

In the interior of the desert, water is one of the main limiting factor for proper livestock production. Vast stretches of grasslands under climax to subclimax cover of *Lasiurus sindicus* (Sewan) remain underutilized due to non-availability of drinking water. In some places the water of tubewell sunk is brackish. Till some permanent arrangement for water supply is made, it will be advisable to provide underground water reservoirs (Tankas) for stock and human consumption on the range. A 'Tanka' with a capacity of 200 kilolitres costing Rs. 16,000/- is sufficient for 100 ha. of a 'Good' condition class pasture. But in areas with high scarcity of water, if only seasonal grazing on carrying capacity basis is practised, one such 'Tanka' will suffice for 150-200 ha. of rangeland (Ahuja & Bhimaya, 1967).

Drinking water requirements of farm animals on the range per animal per day (in litre) during different parts of the year are given below:

Kind of livestock	July	August	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June
ADULTS												
(i) Cown dry	—	—	—	—	—	—	19.3	26.5	28.6	32.8	35.0	41.1
(ii) Sheep	—	—	—	—	—	—	2.1	2.1	2.7	3.2	3.8	4.5
GROWING STOCK (yearlings)												
(i) Heifers	10.6	11.1	12.6	12.9	11.3	9.0	10.2	12.1	13.5	15.0	15.9	17.0
(ii) Ram lambs	2.4	2.4	2.1	1.9	2.1	1.6	1.8	2.2	2.5	3.2	3.8	4.0

The intake of water during monsoons (July-Oct.), when grass on the range is succullent, and autumn and winter (Nov.-Feb.) when temperatures are low is reduced; while it increases during hot weather months. Adults take more water than yearling ones (Ahuja, 1964).

Due to scarcity of water, it has been possible to keep sheep living properly on water supply reduced by 25% of normal needs, even during hot weather, for restricted periods (Purrohit, 1970).

Animals can tolerate higher salt content in water than plants. The intake of water and physiological functioning of sheep given normal water with 1% salt for about a fortnight did not differ significantly. But animals lost their body weight and

intake of water was reduced if the concentration of salt in water was raised beyond that of 1.3% and this is considered unfit for sheep (Ram Ratan, 1970).

Housing

In arid zone, provision of adequate housing for livestocking management programme needs priority as it has not received any attention so far. Housing of livestock could be (a) for migratory stocks which should be moveable, and (b) for stocks reared and managed *in situ*.

Due to recurrent famines, migration of livestock during lean periods, from arid regions to states where grazing is available, is a common feature. As an individual stock owner does not possess land on route to migration areas, therefore, transit animal houses cannot be built. Protection of animals from vagaries of climate, wild animals and theft, en route and in grazing areas in other states is essential. For that, movable or collapsible housing equipment light in weight and easily manageable is needed. For protection, angle iron posts and woven wire will serve the purpose. In case of sudden drop in temperature, small chholderi type material with bamboo poles and tarpaulin or waterproof material to protect the livestock from rain and wind will serve the purpose.

In case of livestock *in situ*, the local practice in arid zone is to keep animals in a compound fenced with thorns of *Zizyphus nummalaris, Prosopis cineraria, Acacia arabica* and other locally available thorny material. This protects the animals from wild animals. In hot weather during day animals take shelter under trees on the range. During cold weather a kutcha thatch is prepared to house youngstock, productive and sick animals. This practice is improper as animal production is reduced due to the stress of weather to the animals.

It is best to select a suitable site for livestock housing. It should be on well drained soils, at preferably elevated site, near a shelterbelt or wind break. A well protected cattle shed, sheep pen, goat pen with high roofs is essential to protect animals against vagaries of weather viz., high temperatures during day, low temperatures during night in winter and rainy period. Young stock, pregnant dams, lactating and nursing animals, draught animals, sick animals and studs need special care in this respect. Prajapati *et al.*, (1969) suggested an animal house opening towards east or south east (to save animals from scorching sun during afternoon, hot and sandy storms and cold winds). For 20 yearling heifers it should have a gross area of 21.336 m × 9.144 m (70′ × 30′) protected by angle iron post and woven wire fencing with covered shade of 2.89 m breadth × 12.192 m length and 2.438 m to 2.743 m height. This provides covered area of 1.765 sq. m supplemented with 7.432 to 9.290 sq. m loafing yard with watering, feeding and mineral salt arrangement per animal. Thatching of roofs with tattas made of thorns of *Zizyphus nummularis* or *Areua psuedotomentosa* etc. insulates the material and provides adequate protection against rigours of cold and heat. Cost of such shade works out to about Rs. 2000 for 20 yearling heifers or 10 cows or 100 sheep. Taking 20 years as life of such pucca structure cost per cow unit works out Rs. 10.0 per year for shelter. Advantage derived by higher livestock production is Rs. 56.88 by beaf; Rs. 60 through milk or Rs. 60 through meat and fleece production per year.

Breeding

There is severe shortage of good and improved sires in arid regions. Use of Artificial Insemination to get better progeny from animals in the desertic areas is not a practical proposition, in the present days, due to difficult communication facilities. Recording of production from animals is another problem due to frequent migration and communication troubles. The only solution is to open up sire depots where sires produced by promising dams and sires may be raised and distributed to local stock-owners. It is advisible to prefer the sires from Livestock breeding farm where all possible records of animals are maintained. The stockowners who are given these studs should keep the sires in proper condition.

Assessment of performance of animals (Cattle)

For periodical assessment of changes in body weight for growth rate and requirements of feeds, it is essential to know the body weights of animals. Small animals like sheep and goats could be weighed with the help of spring balances etc, but heavier animals like cattle need weighing machines which are difficult to maintain and handle in the interior of desertic areas. Therefore regression equations have been evolved (Ahuja *et al.*, 1964; Ahuja, 1965) to estimate body weight of cattle with the help of heart girth and these are given below:

Adult cows	$Y = 5.1180; \quad X = 479.7$
Male Calves	$Y = 3.053; \quad X = 220.9763$
Heifers	$Y = 2.8798; \quad X = 204.3452$

Where Y is the estimated body weight (kg) and X is heartgirth (cm).

Thus for proper livestock production for improving economy in the arid regions, it is essential to use the pastures rationally. This will also speed up supplies of better quality livestock from arid regions to other states for increasing their animal production.

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