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EFFECTS OF GOAT HUSBANDRY ON THE DEVELOPMENT OF THE LANDSCAPE

by

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Forest grazing and desertification

Due to climatic conditions nearly one third of the land surface of the earth is desert or semi-desert. The vegetation in these arid or semi-arid regions is increasingly threatened by man-made desertification, a consequence of excessive and archaic land-use practices. People living in these areas have but few alternatives of survival. One is the practice of forest grazing, characteristic for all arid regions but as detrimental to vegetation and soils as shifting cultivation in the humid tropics. Both land-use forms have been practised for thousands of years but serious consequences started showing after certain threshold levels of the carrying capacity were exceeded due to population pressure. Particularly in recent years the situation has drastically deteriorated, with no stabilization or reduction of population growth in sight. In addition, scientific and technical progress is enabling the individual and the community to interfere more profoundly with ecosystem processes than ever. Development aid projects of the past years have contributed their share, increasingly entailing "positive feedback" impulses, i.e. a vicious circle of mounting population pressure, increasing destruction of natural resources, scarcer supplies, introduction of "improved" technologies, further increase of population etc.

The example of goat grazing within sylvo-pastoral management shows clearly that future catastrophes can be avoided only by determined intervention and under consideration of all interdependencies of the system "forest-pasture".

Destruction of forests by uncontrolled grazing

"Forests precede mankind, deserts follow in its wake." The truth of this statement has recently been confirmed in many ways at the UN Conference on Desertification (UNCOD) in Nairobi in 1979. Inadequate and excessive land-use practices have been identified as the reason for desertification in many countries. This applies largely to grazing in the forest, and many examples of goats being the main cause of desertification have been cited. As on many occasions before, the goat was singled out as the "razor of forests" (or any other vegetation).

At present the stock of goats is estimated to reach 400–440 million, which corresponds to one third of all ruminants. More than 75 % of them are raised in the tropics and the subtropics.

It is very difficult to estimate reliably the extent of damage by pastoral land-use in terms of area or financial loss. This does not invalidate the statement that over vast stretches of land, particularly in semi-arid, arid and in mountainous regions the intensity of destruction by forest grazing in general and goat browsing in particular is extremely high. Examples are the Mediterranean region, the Near and Middle East and large parts of arid Africa. Destruction affects primarily the tree and shrub vegetation where browsing animals destroy regeneration and damage and degrade established plants. As a consequence, however, increasing destruction of the vegetative cover leads to soil erosion and irreversible destruction of the ecosystem. It is therefore necessary to examine carefully whether the damage caused does not exceed (by far) the benefits of goat husbandry. The intensity of grazing damages depends on several frequently interdependent factors. These are primarily

- the composition of herds by species (cattle, goats, sheep), age structure and number of heads;
- duration and frequency of grazing on the same area and the seasonal grazing pattern;
- the type of forest and site characteristics (particularly morphological soil structure and slope);
- type of forest regime, management intensity, management objectives and silvicultural treatments;
- ways of using the forage reserve of the forest.

It is evident that the extent of damage is closely related to the number of goats kept within a particular area. Although this correlation is significant it must be examined whether the increase in the number of goats is the reason for the destruction of the vegetation or its secondary conse-

quence. If for example cattle cannot find sufficient forage because overstocking with animals or other inappropriate land-use practices have destroyed the grass-cover, people will switch to intensified goat raising.

Why are goats so destructive to trees and shrubs? This is mainly attributable to their feeding habits. Goats eat not only grass, herbs and parts shed by trees but also significant amounts of young shoots, twigs, fruit and bark. The proportion of "ligneous forage" depends on the overall feed supply in an area and the floristic composition of the ligneous vegetation – but in many cases it exceeds 50 % of overall intake. In addition, goats are less selective in their forage intake than other domestic animals. Particularly in times of scarcity they eat almost anything, sparing neither particular species nor particular parts of plants. Goats are able to climb into smaller, leaning trees; they rise on their hind legs to extend their reach. While with lush vegetation, as in the moist tropical forests, goat grazing entails practically no serious problems, the situation is entirely different with the marginal vegetation of arid and mountainous regions. But exactly here we observe the highest concentration of goats because other animals do not find sufficient forage. Another fact is that the reproductive cycle of goats is shorter than that of other domestic animals. Hence, the pressure on the vegetation may build up quite rapidly.

Erosion, karst formation and desertification may be consequences of the action of the animals, i.e. by browsing, by damaging plants, by trampling or by destructive actions of herdsmen such as pollarding, breaking branches, excessive litter removal, or burning.

In view of the order of magnitude of destruction through forest-grazing it is understandable that foresters the world over are fighting with great determination to prevent the most serious forms of forest destruction. Actions are predominantly directed against goats, which cause the severest damages to trees and shrubs. In many parts of the world foresters consider goats the arch-enemy of forests and forestry.

In several countries the efforts of foresters to protect forests against degradation by goats found the support of governments, e.g. in Cyprus, Yugoslavia, Israel and Tunisia. The success of government actions was varying, since law enforcement met with considerable difficulties.

Problems of incompatibility of management goals

The problems of conflicting interests between forestry and goat grazing may be demonstrated by examples from four sectors:

a) For the national economy in semi-arid, arid and mountainous regions the functions of and benefits from forestry are of great significance:

- forests contribute to the conservation and improvement of the environment, to the prevention of erosion, desertification and karst formation (protective functions);
- forests supply various products: wood for energy, construction and work material, diverse food and forage products, extractives and local pharmaceuticals (productive functions);
- forests contribute towards security and improvement of socio-economic conditions and infrastructure by providing jobs, income, and reserves for emergencies (social functions).

Particularly in countries where agriculture is the main source of income, full support must be given to forestry and forest resource management as an essential factor of the national economy.

The population in rural areas sees this role of forestry under different aspects. For daily subsistence goat keeping is much more important to the individual than observance of the common good, the significance of which is frequently not recognized. Utilization of public forests by goat grazing is considered a traditional privilege. But the private forest owner too may derive profit from forest grazing which provides him with a continuous source of income quite in contrast to the long-term, low-revenue investment in timber production.

Hence, the most salient problem concerns the conflict between individual and common interests or the harmonization and optimization of diverging management objectives.

b) No farmer or horticulturist would ever think of admitting goats for uncontrolled grazing to land under productive management. This principle should also apply to plant production in forests but it is permanently violated the world over (because the goat as the domestic animal of the most destitute part of the population generally evades rational and controlled management practices). But this is the very root of the problem. Not goat keeping as such but its absolutely archaic management leads to conflict. It is therefore urgent to reconcile medium- and long-term forest management objectives with the practice of natural resources utilization by goat grazing within the framework of small-holder or nomadic systems economy. The ultimate goal, however, must be the introduction of sustained-yield management of the forest resource base.

In sharp contrast to the past practice of exploitation without compensation livestock owners must accept the necessity of regular investment into the conservation of the resource base if the practice of goat grazing in the forest shall continue.

c) In semi-arid and arid regions the goat is an essential factor and, in

extreme cases, nearly the only base of existence assuring a minimum supply of nutrition and income. As long as there are no alternatives people must continue goat keeping for survival even if it means damaging or destroying common natural resources by illegal practices. Unavoidably, this leads to a confrontation between existing law (e.g. forest laws) and traditional local land-use. A clear, demand-oriented land-use regulation is not only the precondition but also the essential problem of co-existence of forestry and pastoralism.

d) For the development of animal husbandry in semi-arid and arid regions goats are of great interest. The goat adapts extremely well to different natural conditions as well as to economic exigencies. Neither goat husbandry nor goat products face mentionable social taboos. Goats, at least in arid regions, prove highly resistant to disease, and their management is particularly free of risks. They are also very efficient forage converters, accepting nearly all of the available phytomass as forage and making better use of fiber-rich substances than other domestic animals. Water demand is very small even in hot, arid regions, a considerable advantage over other ruminants. Last but not least, it should be pointed out that goats provide various valuable products: milk, hair, meat and skins. Intensification of goat husbandry is recommendable and may be the only answer to cope with the increasing needs in overpopulated, arid regions. At the same time this development constitutes the most serious threat to the conservation of forest resources and a balanced environment.

*Potential solutions to reconciling the conflicting interests
of forestry and goat husbandry*

Continuing or even aggravating the confrontation between forestry and goat husbandry provides no solution towards satisfying the needs of rural populations in the tropics and subtropics. New ways of balancing diverging interests must be explored. Where such attempts have been made they should be continued, improved and perfected. Where no such ways are known, both sides should seek an exchange of thoughts and try to understand the viewpoint of the other side. Only by cooperative strategies can the diverging interests of foresters and animal holders be reconciled.

Spatial separation of forests and pastures

A clear separation of forestry and pastoral land-use seems to be the best solution for avoiding conflicts. This has been the most successful approach taken in many parts of the temperate zone. It permitted considerable increases of productivity in forestry and livestock management (i.e. goat

husbandry). Although the natural and economic circumstances in many subtropical and tropical countries make such a separation more difficult and less promising, this methodical concept should be seriously considered.

Separation by elimination

At least theoretically separation may be achieved by removing or even eliminating one of the antagonists from a particular region. This corresponds to the attempts made in some countries with partial or even complete prohibition of goat husbandry. On the other hand, goat husbandry could be given priority over forestry for regional development in a particular area, accepting the implication that forestry activities or the conservation of forests are unfeasible or even undesirable in this area.

Separation of forestry and pastoralism by fencing

Such methods are frequently applied particularly by protecting important or sensitive forest areas by fences or by guards such that grazing by goats takes place only after a defined period (e.g. after a five to ten year establishment or regeneration period) or is not permissible at all. Generally, such a protection is very cost intensive (at least the protection against goats is more expensive than against other domestic animals) and it may also result in increasing pressure of herds on the unprotected areas and forests.

In general, only very vast stretches of forest or range-land are extensively utilized by forestry or pastoral activities. More effective management combined with increased productivity would, however, be facilitated if future activities could be concentrated on the most suitable sites. This would imply a reduction of the total area under forest management but an increase of high-yield forestry, without the risk of permanent encroachment by goat grazing. On the other hand, intensive pastoral management could be performed on particularly suitable areas, eventually supplemented by the cultivation of fodder plants. Hence, instead of fencing in forest areas, goat raising is restricted to a particular area. This is the first step of transition to keeping goats in fenced feed-lots or stables. Unfortunately, besides many other problems, this concept is faced by the difficulty of securing adequate fodder supplies and appropriate sanitary conditions under the existing socio-economic structures of many developing countries.

Secondary utilization of forests by regulated goat grazing

The archaic, destructive ways of forest grazing as still widely practised should be replaced by controlled utilization from which both forestry and

pastoralism could mutually benefit. Promising methods have been developed.

Partial substitution in incompatible situations

Under this concept goats are partly replaced by animals causing less damage, as for instance, sheep. Conversely, one could plan to transform endangered forests by introducing less palatable species and by changing the silvicultural management system. Damage in a high forest is likely to be less severe than in a selection forest or in shrub plantations.

Reduction of the number of animals per area unit

An analysis of the relevant literature and field observations of the damage of goats to forests indicate that not goat grazing as such but the excessive number of heads per forest area is the cause of destruction. This can be clearly seen in some regions of Africa and in India. A permanent charge of 1–4 goats per hectare sooner or later leads to a complete disappearance of the vegetation cover. Since the rural population depends on goat husbandry as a steady source of food and income the only solution is the genetic improvement of breeding stock, with the aim of obtaining increased revenue without increasing the size of the herd. This could lead to a gradual reduction of pressure on the environment as has been demonstrated by many successful projects.

Temporal sequence of utilization (rotation)

Schemes of variable management in time and space can be successfully practised in the tropics and subtropics. After completion of the comparably short rotation cycles of 1–7 years for fuelwood plantations and 5–15 years for small-size timber production intermittent grazing on cut-over forest land could be planned. It is also possible to delimit smaller areas within the forest which are only seasonally closed to grazing, allowing for sufficient regeneration of forage plants and avoiding excessive damage to existing trees.

Protection of single plants

If by common understanding within a community the surrounding vegetation is to be utilized by goat-grazing, measures must be taken to protect the regeneration of valuable fruit trees. Experience has shown that guards are not too efficient. Hence, mechanical means of protection such as wire mesh, plaited branches or special pottery must be used for individual plants. This is a relatively expensive technique because maintenance and occasional repairs are always necessary. An alternative, the application of repellent chemicals, unfortunately has been largely neglected,

particularly when compared to the efforts undertaken in many countries against browsing by game animals. The claim that effective treatments against goats are not available has yet to be proven. This is obviously an old problem and literature cites Democritus (474–370 B.C.) using foul, decomposed river crayfish as a goat repellent (Seidensticker 1886). A modern goat repellent must comply with the following standards:

- it must be non-toxic for humans, animals and usable plants;
- the repellent efficiency rate must reach 95 %;
- it must have a high adhesive force and should stick 8–10 months to leaves, shoots and branches;
- it must be cheap;
- it must be available everywhere and anywhere, be admitted for application in the respective country, easy to transport, suitable for local manufacture, and permit long-term storage;
- it must be easy to apply and require only limited quantities.

Introduction of controlled grazing in forests

From the number of successful methods only two shall be cited as examples: the western United States, where range-management, e.g. in ponderosa-pine stands, has been practised for more than 60 years and the “aménagement sylvo-pastoral” developed in francophone countries. The preconditions, however, are highly productive soils, little pressure by man and animals, and flat rather than hilly or even steep terrain. Under such conditions the goat can fulfill a number of useful functions. Intensive grazing is useful on firebelts, in open coniferous forests and on clear-cut forest land, for keeping ground vegetation low; this reduces fire hazards and facilitates later reforestation. Since goats prefer woody plants they keep bushes and shrubs low and eliminate regeneration which would otherwise suppress grass vegetation. Examples from North America but also from range-lands in West and East Africa have shown that on areas protected against goat browsing the bush vegetation becomes so dense that the grass cover is eliminated after a few years.

Forage production as a forest management goal

The above mentioned separation of areas under intensive management on selected sites may be meaningfully extended by growing forage species for goats on areas allotted to forestry. For many regions of the tropics and subtropics this seems to be a more realistic and promising approach than timber production, provided appropriate sites can be selected.

Plantations for the protection and improvement of pastures

This concerns primarily shelter belts, but also shade trees, and trees and shrubs planted to prevent erosion. Their overall effect is an increase in productivity of pastures; in many arid regions grass grows much better and for a longer time under the shelter of trees because of improved soil moisture retention.

Utilization of grass, fruits and litter in the forest

Inside of many plantations in the Sahel the growth of grass is much more vigorous than on open ground, probably as a consequence of soil preparation. This grass can be harvested and sold on the local markets or the village people may cut it for their own animals. Once the trees have grown high enough goats may be allowed to graze in the plantation if this is not detrimental to natural regeneration, e.g. if the plantation is to be clear-cut. In addition to grass also leaves and fruits of trees and shrubs may be collected as fodder without affecting forestry interests. However, excessive litter removal will lead rapidly to deficiencies of organic matter and minerals, causing long lasting losses of soil fertility. The same philosophy applies to the practice of pollarding: The essential prerequisite is the adequate control of utilization practices.

Establishment of natural forests enriched by fodder plants

Natural regeneration of the forest vegetation eventually enriched with valuable fodder species and grass may permit using these areas in rotation as permanent grazing grounds with a strictly controlled number of heads.

Establishment of special fodder plantations

Such plantations have already been established and more than 100 species of trees and shrubs have been recognized by observation in the field or by scientific analyses as valuable fodder plants. Trees and shrubs may be grown in the stands or as solitary plants to improve forage reserves for all animals. Returns obtained may substantially exceed those from wood or other secondary forest products; eminent examples are *Acacia albida* in Africa and *Leucena leucocephala* in South East Asia and South America. There are other species in all continents giving similar returns.

Research needs

Probably out of resignation or because it was hoped that a solution of existing problems might be brought about by others or by economic development foresters as well as goat keepers have done little in the past to

overcome existing conflicts and hardly any attempts have been made to achieve some degree of cooperation. It is equally true that many problems falling in the domain of research have not been adequately covered. The following items are but a few examples of such research tasks:

- Definition of criteria for identification and classification of areas which should be out-of-bounds to goat grazing. Such a restriction should be based on convincing facts but include also suggestions how protection could be effectively achieved.
- Design of management schemes permitting a combination of forestry and goat grazing. This could possibly be investigated with simulation models which optimize the productive potential of forestry and goat husbandry using maximum/minimum factors.
- Development of effective procedures for protecting individual trees and shrubs planted on fields and pastures or elsewhere outside of forests which are particularly valuable fodder plants.
- Identification, breeding and selection of tree and shrub species with high value as fodder plants and development of efficient silvicultural and utilization procedures.
- Development of physical or chemical pretreatments of lignocellulosic materials to make them suitable as animal fodder. Many countries have achieved considerable progress in manufacturing cattle feed. It is likely that goat fodder could be produced since goats utilize forage with much higher crude-fiber contents than cattle.
- Investigation of ways to increase productivity of goats by breeding and selection, offering means of reducing their total number and thus the damaging efforts on the vegetation.

Aspects of grazing

Statement of the problem

The goat is constantly being accused of destroying vegetation and contributing to erosion. The fact is that the goat is usually kept in locations with too low a production potential in too large numbers and thus contributes to an increase in erosion. The grazing habits of the goat differ in some important points from those of cattle and sheep:

- Goats can nourish themselves largely from fibrous plants.
- Goats can chew off plants low down and selectively.
- Goats have a low moisture requirement.

Thanks to these qualities, goats can survive where cattle and sheep have long disappeared. Thus goats are the last users of areas threatened by

erosion. They can utilize this area, but also destroy the last remnants of vegetation.

Because goats are then the last means of subsistence for the inhabitants of such a region, overgrazing is a regular practice which leads to worsening grazing conditions. This leads to a truly vicious circle. On the other hand, the observation can be made that the causes of often pitiful conditions of the pastures are seldom recognized. The tendency is to consider the case hopeless and to blame it on unfavourable climatic and soil conditions.

Only if the area has been fenced off for a while or grazing limited by other means, does it become clear what could actually grow on that location. Regeneration of the vegetation is only possible if reproducible vegetation is still available. If desertification has set in it is practically impossible to reverse the destruction of ground and vegetation.

The extent of damage by goats can be made clear by means of an example. Even if this example is not necessarily transferrable to other regions, it clarifies the general problem of overgrazing.

Example

Location

The studies were made in the southeastern coastal area of the Island of Hawaii at about 400 m altitude. The average yearly temperature is around 24 °C with slight seasonal variations. Precipitation reaches a yearly average of 800–900 mm, whereby the months of May to September are considerably drier than the winter months. It rarely occurs that no rain at all falls in one of the summer months. The ground is very flat and is situated on porous lava varying in age (partly only a few centuries old).

Vegetation

The current vegetation is a result of about 200 years of constant grazing, which was doubtless much weaker in earlier decades than at present. One can assume that the region was characterized by a loose seasonal dry forest composed solely of endemic species. The forest has long disappeared (except for a few isolated examples of microlocations which are inaccessible) and has given way to a vegetation dominated by grasses. These are primarily grass varieties suited to grazing which have been transferred from other tropical and subtropical areas.

Tests

The study was relatively easy to set up. Fenced-in areas were set up in various places from which goats were barred. The vegetation within and outside of the fenced-off areas was analysed and compared using various methods for studying vegetation, which cannot be discussed here in detail.

Results

Already after a few months the vegetation inside the fence was visually distinguishable from that outside, not only through its larger biomass, but also through the fresher colours. In addition there was a rapid shift in species.

Whereas on the outside rather unproductive annuals dominated, within a year there were already woody plants and perennial grasses where goats did not graze. The analysis of the vegetation on a location with rather shallow soil produced the results shown in Table 1. The values in Table 1 show the degree of vegetation coverage in percent of the total surface. The sum of all degrees of coverage both inside and outside the fence amounts to 100%. According to estimates the phytomass of Bermuda grass (*Cynodon dactylon*) was 20 times larger inside than outside, although the percentage of the total coverage was larger outside than inside. Woody plants were found only inside in larger numbers. Perennial grasses such as *Heteropogon contortus*, *Rhynchelytrum repens*, *Sporobolus africanus* and *Hyparrhenia rufa* were only found inside as well.

The percentage of unproductive ground surface (litter), open ground, rock, and goat waste on the outside was 24% at the time of the first measurements and rose to 40% a year later.

There was no open ground on the inside at all; only the percentage of dead plant material rose, which is understandable since the area was unused.

A particular phenomenon was the appearance of the strongly creeping legume *Canavalia kauensis*, which formed a thick web of plant mass already a few months after the erection of the fence. The species had been unknown up to that point and could not be found outside the fence (St. John 1972). Only an intensive search produced a few of the large seeds outside the fence; they had been uncovered by wind erosion. Sprouting seeds could also be observed during the moist months, but they were immediately bitten off as soon as the first leaves appeared and died out. The existence of still sproutable seeds can be traced to the fact that in the past decades the pressure from the grazing goats was, at least periodically, considerably reduced, so that *Canavalia kauensis* was able to reproduce (Baker and Reeser 1972).

Conclusions

It would be a mistake to blame the goat, as a grazing animal, in any way for the successive destruction of its fodder basis in the case of bad management. If it is clear that in areas where goat keeping is a vital means of subsistence for the inhabitants, the natural fodder basis is not only

Table 1 – Degree of coverage inside and outside the fenced-off area

Species	inside				outside			
	6.7.71	28.12.71	29.3.72	7.7.72	6.7.71	28.12.71	29.3.72	7.7.72
<i>Grasses</i>								
<i>Eragrostis tenella</i>	10.7	0.6	0.5	(+)	30.0	20.0	34.0	29.6
<i>Cynodon dactylon</i>	26.4	18.8	14.2	21.7	31.4	18.8	28.4	32.8
<i>Chrysopogan aciculatus</i>	.	+	1.1	.	1.4	+	+	0.4
<i>Sporobolus africanus</i>	4.3	+	0.6	1.1	.	.	.	.
<i>Rhynchelytrum repens</i>	0.7	2.8	5.1	12.5	.	.	.	.
<i>Heteropogon contortus</i>	+	1.2	+	+	.	.	.	.
<i>Melinis minutiflora</i>	.	+	+	+	.	1.6	+	0.8
<i>Digitaria pruriens</i>	.	23.2	13.7	2.3	.	0.4	6.8	0.4
<i>Andropogon glomeratus</i>	.	.	+	+	.	.	.	.
<i>Hyparrhenia rufa</i>	.	.	.	+	.	.	.	.
<i>Sedges</i>								
<i>Bulbostylis capillaris</i>	.	.	(+)	(+)	0.4	1.6	0.4	0.4
<i>Cyperus brevifolius</i>	.	+	2.4	(+)	1.3	4.4	+	1.2
<i>Cyperus compressus</i>	.	+	(+)	.	.	+	+	.
<i>Herbs</i>								
<i>Phyllanthus niruri</i>	.	.	.	.	+	1.2	+	.
<i>Euphorbia hirta</i>	.	.	.	.	+	3.8	+	+
<i>Portulaca oleracea</i>	.	+	+	.	.	.	+	.
<i>Gnaphalium purpureum</i>	.	.	.	.	.	+	+	.
<i>Linaria canadensis</i>	.	.	(+)	.	.	.	+	.
<i>Sisyrinchium micranthum</i>	+	.	.	.	.	+	.	.
<i>Oxalis corniculata</i>	.	.	.	.	.	+	.	.
<i>Veronica cinerea</i>	.	.	.	.	+	.	+	+
<i>Conyza sp.</i>	.	.	.	.	.	.	+	.
<i>Portulaca cyanosperma</i>	.	+	.	.	.	.	.	+
<i>Herbaceous legumes</i>								
<i>Canavalia keuensis</i>	45.7	48.0	51.1	38.8	.	.	S	.
<i>Desmodium triflorum</i>	8.6	1.2	1.1	0.4	7.3	0.4	+	0.8
<i>Desmodium uncinatum</i>	.	.	.	.	.	+	.	.
<i>Woody plants</i>								
<i>Indigofera suffruticosa</i>	+	+	+	+	.	S	S	.
<i>Waltheria indica</i>	+	2.4	1.1	2.3	.	S	S	S
<i>Cassia leschenaultiana</i>	1.4	2.4	1.7	0.5	.	S	S	.
Litter	1.4	.	7.4	19.4	17.5	14.4	5.2	16.4
Open ground	.	.	.	.	17.5	23.6	12.8	9.6
Rock	0.7	.	.	.	6.0	14.4	11.6	17.2
Goat waste	.	.	.	.	0.4	.	.	0.4

S = seeding.

The dates 6 July, 1971 and 7 July, 1972 were in the dry season.

The dates 28 Dec., 1971 and 29 March, 1972 were in the moist season.

limited but also very unstable, the following basic demands can be made as a basis for orientation:

1. The first step must be a drastic reduction of the existing goat population. It can suffice to simply remove the unproductive members of the herd, which provides a considerable relief for the pasture without reducing the output useful to humans.

2. An achievement of a balanced condition between fodder and grazing animals must be attempted whereby the highest possible level of production is attained for the pasture and the grazing animals. Plants which are chewed off to the roots cannot be productive. Only a stand with a high leaf surface index can achieve the highest possible assimilation rates.

3. In the case of extensive pastures one must make the animals use the area evenly by herding or rotational grazing. The development of simple rotation systems provides the best assurance for this.

4. The natural fodder basis can be considerably increased through the introduction of fodder plants. A whole spectrum of plants come into question in semi-arid to subhumid climatic areas. These range from annual legumes such as medicago species and *Trifolium subterraneum* to grasses and herbs resistant to dryness such as *Eragrostis curvula*, *Atriplex halimus* and *Opuntiae*, to shrub and treelike legumes such as *Leucaena leucocephala* and *Acacia albida*. It is evident that these plants can only be used to an advantage on a permanent basis if a suitable herd management can maintain its productivity and reproduction.

5. Lack of feed and damage to vegetation does not appear year-round, but mostly in the dry periods, since long dry periods are the rule in those areas with the highest rate of goat-keeping. An addition of fodder during the dry periods could, therefore, create a higher productivity and preserve the vegetation. In addition to fodder plants which provide fodder even in the dry period fodder plants could be planted during the moist period, which could be conserved for the dry period. Naturally the planting of fodder plants can only be taken into consideration in particularly favourable areas.

If an optimal productivity of a pasture can be achieved and maintained through the above-mentioned measures, the pasture will also be in a position to permanently support a goat population which can undoubtedly be larger than the population which vegetates on a totally overgrazed area on the edge of a minimal subsistence.

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