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Hema System: Traditional Conservation of Plant Life in Saudi Arabia

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ABSTRACT. Traditional conservation of plant life by the *hema* system has been successfully achieved in the SW mountainous region of Saudi Arabia. The unwritten, but very respectable rules of the tribe are, in fact, the most effective factor that keeps on the running of the system since pre-Islamic era.

Three representative hemas, namely: *Hema Bani Sar, Hema Thamala* and *Hema Sakhayet,* have been studied ecologically. The plant cover and soil characteristics in- and outside the hemas *(Ahmia)* vary considerably. Overgrazing outside the hemas has bad effect not only on the plant life but also on the soil development. Inside the *hemas,* the condition of the plants differ according to the state of grazing. In the main channel and on the lower zones of the side-slopes of *Hema Sakhayet* and *Hema Thamala,* where grazing is allowed only for cattle, the aerial parts of the grazeable plants (mainly grasses) are absent. On the higher zones of the slopes, the grasses and other plants grow well. In *Hema Bani Sar,* where grazing is strictly prohibited for all livestock, the vegetation, in general, is relatively ricker and the soil shows no symptoms of erosion.

Introduction

The traditional *hema** system of plant life protection is one of the oldest known forms of natural resource conservation in the world. In Saudi Arabia, it dates back to the pre-Islamic era and has continued since then as a respected tradition by muslim leaders. In spite of the contradictory views about the rights of ownership and the use

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*Hema in arabic means: Land under protection (plural = Ahmia)

of the *hema*, yet their persistence through the ages provide a live evidence of their worth and suitability as an unparalleled traditional means of plant life conservation.

The published literature about the *hema* system in Saudi Arabia, as far as we know, is fragmentary. Draz[1] was the first to describe this system in his book (written in Arabic) entitled "Rangeland Development in Saudi Arabia". Later on, the same author[2], further elaborated on the possibility of receiving the hema system and extending it to the other Middle East Countries. The other references dealing with the hema system and its application in range improvement strategies in Saudi Arabia include: Allred[3], Kingery[4], Duba and Ellis[5], Draz[6], Batanouny[7], ..., etc. However, these references were based on insufficient data about the hema system in general.

The present work includes the results of an integrated ecological studies (geomorphology, soil, plant life and animal life) of three of the *hemas* of the South Western (Hijaz) mountains of Saudi Arabia, namely: *Hema Bani Sar, Hema Thamala* and *Hema Sakhayet,* Fig. 1.

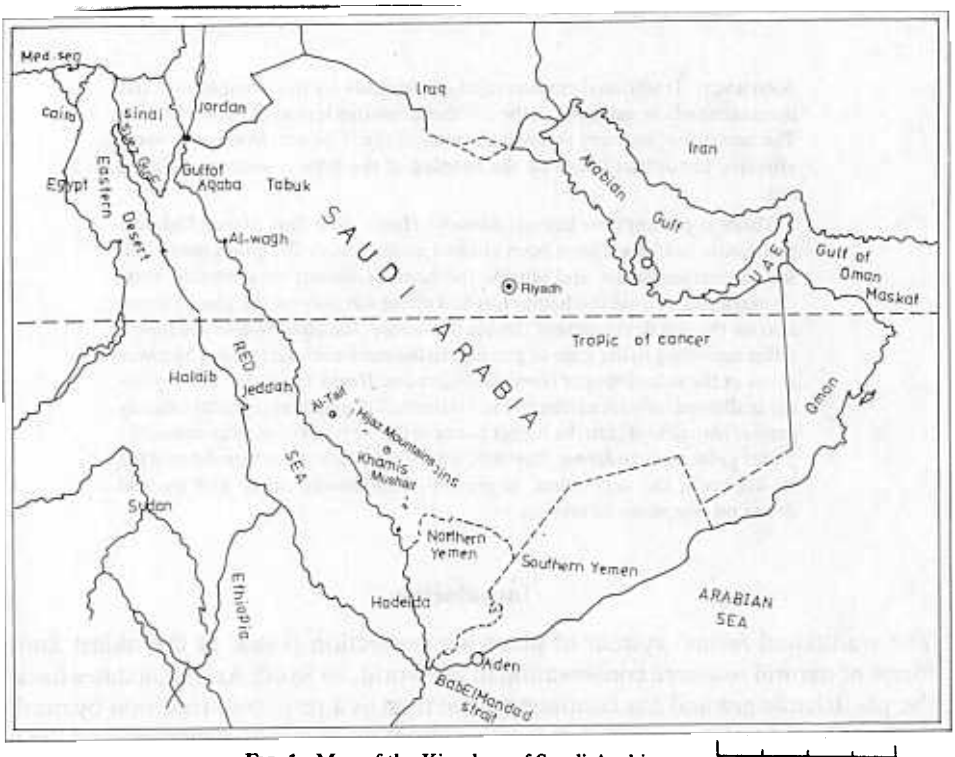

FIG. 1. Map of the Kingdom of Saudi Arabia.

General Remarks

The Hema System might be defined as "a set of regulations controlling the extent and intensity of utilization of resources". In Saudi Arabia, this conservation and pro-

tection system, started before the Islamic era (570 A.D.) and was greatly encouraged by the Prophet Muhammad and his successors, who were aware about their importances for conservation of rangeland resources. According to Draz[2,6], the *hema* reserves might provide a means for range improvement in the Arabian Peninsula and other parts of the Middle East. The potential of this range system stems from the fact that it is a traditional means of conservation imbedded in the extant value system of at least some parts of Middle Eastern countries. As a result, revival and extension of the institution for range improvement based on rational principles would not require the introduction of foreign social institutions or values into the local cultures.

Classification of *Ahmia (hemas)* can be based on: a) extent pf grazing and/or cutting controls, and b) social unit control[2,8]. Five types of *Ahmia* have been recognized by Draz[6] according to the extent of grazing and/or cutting. These are:

Type I : No grazing, but cutting of grasses is, however, permissible during specified periods and droughts.

Type II : Grazing and/or cutting of grasses are partly permitted but restricted to certain seasons of the year.

Type III : Grazing is permitted the year round, but the kind and number of animals permitted are specified, mainly cattle and donkeys. No restriction on hay cutting after grass mature.

Type IV : Beekeeping hemas in which grazing restrictions are relaxed after the flowering seasons.

Type V : Cutting of trees is prohibited in the *Ahmia (hemas)* which are aiming at protecting forest trees, *e.g.* Junipers, Acacias, ... etc. Natives can cut trees only in case of emergency or great need, such as rebuilding of houses, mosques or schools.

According to the social unit control, *Ahmia* can be classified into three types: tribal, village and individual. The tribal *hema* is controlled and used by several (up to ten) villages which belong to the same tribal section. The village *hema* is smaller than the tribal one and it is controlled and used by a single village. The third type or individual *hema* (is called also Al-Hojrah)* is much smaller and is usually located next to the cultivated field of the owner. It is always fenced with stone walls.

In all types of *Ahmia,* the regulation of the use of a hema is closely integrated in the tribal tradition. Violation of these regulations used to be punished by slaughtering one or more of the trespassing animals. More recently, violators may be subjected to warnings, fires and even imprisonment.

In Saudi Arabia, the presence of many (< 200) *Ahmia* in the Hijaz mountains indicates that the *hema* system probably flourishes better around the farming areas of this region than elsewhere in the free grazing zones.

Methodology

Out of more than 200 *hemas* of the Hijaz mountainous region of Saudi Arabia,

*Al-Hojrah is an arabic name of a room.

three hemas have been selected for the present study, namely: *Hema Bani Sar, Hema Thamala* and *Hema Sakhayet.*

Until this study, the extent and position of the three *Ahmia* were known only approximately. As no maps of either area are available at a scale larger than 1:500,000, the first objective as to compile satisfactory base maps of the areas to serve as a base for further study.

The only aerial photographs available of the general area were monoclimatic ones flown in 1956 at a scale of 1:60,000. These were examined stereoscopically on relevant soil geomorphological and geological information plotted on transparent overlays. The features of one of the study *Ahmia,* namely *Hema Thamala,* is mapped as seen in Fig. 2 which includes line of drainage, ridges, fields, buildings pre-1956, stone walls and small private hemas.

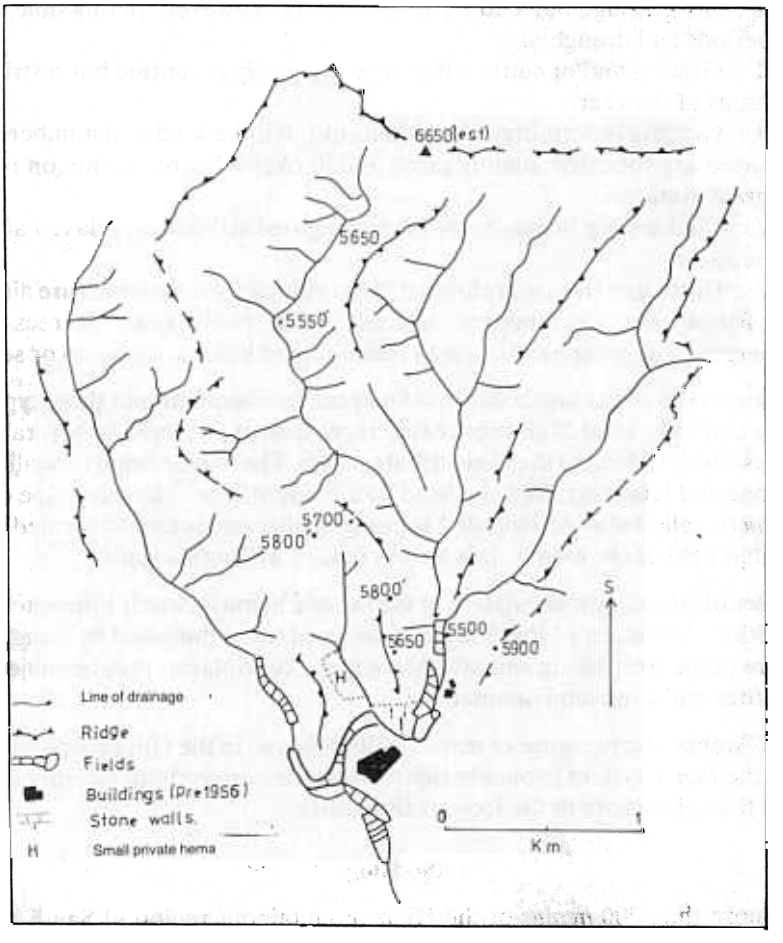

FIG. 2. Soil map of Hema Thamala, Taif Mountains, Saudi Arabia.

Field work was performed during 1981-1982. Soil samples of representative profiles inside and outside *Hema Bani Sar* and *Hema Thamala* were collected from the principle horizons, described according to FAO[9] and subsequently analysed using the methods adopted by Black[10]. The soils were classified according to the soil taxonomy system given by USDA[11].

Soil erosion has been measured using soil survey manual USDA[12] and Helmut *et al.*[13].

The plant cover inside and outside the *Ahmia* was studied qualitatively and quantitatively using method described by Braun-Blanquent[14] and Kassas and Zahran[15]. For plant identification, authors depended upon Tackholm[16] and Migahid[17].

Ecological Characteristics

The three studied Ahmia are located in the mild rainy Hijaz mountainous SW region of Saudi Arabia, Fig. 1. *Hema Bani Sar* is present near Khamis Mushait City (Lat. 18°18′N, Long. 42°48′E and Alt. 2057 m) while *Hema Thamala* and *Hema Sakhayet* are present near Taif City (Lat. 21°29′N, Long. 40°32′E and Alt. 1457 m).

TABLE 1. Climatic particulars of Taif and Khamis Mushait Meteorological Stations, Hijaz Mountains, SW Saudi Arabia (taken from surface climatological report, Ann. Env. Rep., Gen. Direct. of Meteorology, Saudi Arabia, 1977).

Month	Taif			Khamis Mushait		
	Temp. (°C)	Rainfall (mm)	Humidity (%)	Temp. (°C)	Rainfall (mm)	Humidity (%)
Jan.	14.8	9.3	59	13.7	8.1	65
Feb.	16.2	5.7	49	15.2	16.8	56
Mar.	19.4	19.8	44	17.0	52.9	55
Apr.	21.9	29.8	40	13.9	34.2	49
May	24.9	34.8	34	21.3	34.7	48
Jun.	28.3	4.5	21	24.2	73	36
July	27.9	1.5	23	23.2	23	46
Aug.	28.1	6.3	24	23.3	18.1	47
Sept.	27.1	5.2	26	22.5	7.5	33
Oct.	22.5	6.0	34	18.9	0.4	33
Nov.	18.5	26.8	54	16.2	18.1	53
Dec.	15.3	6.5	57	13.6	21.6	64
Mn Max.	25	–	60.5	25.5	–	73.7
Mn Min.	10.6	–	14.4	10.4	–	22.1
Av. Anpual	18.1	156.2	38.7	17.8	242	46

As seen in Table 1, air temperatures of both areas are almost comparable with mean maxima of 25.5 and 25°C, mean minima of 10 and 10.6°C and average annual of 17.8 and 18.1°C in Khamis Mushait and Taif, respectively. Rain is expected all year round but the total annual amount of precipitation on Khamis Mushait (about 242 mm) is relatively higher than that of Taif (about 156.2 mm). Hail usually occurs in the period

of April-September. The relative humidity is, also, relatively higher at Khamis Mushait (mean maximum = 73.7%, mean minimum = 22.1% and average annual = 46%) than at Taif (mean maximum = 60.5%, mean minimum = 14.4 and average annual = 38.7%).

1. Hema Bani Sar

Hema Bani Sar is situated about 2 km north of Bani Sar village. It has NNW-SSE orientation, approximately 4 km long, 1.5 km wide and covers about 5-6 km^2. Its eastern and southern margins run along an unpaved road, the western margin follows the course of a stream bed and the northern boundary occurs in area of relatively steep slopes. In general, *Hema Bani Sar* occurs in deeply dissected ancient rocks, with the exception of bed rocks, the slopes (range between 15 and 35°) covered with very shallow gravelly sandy loam soil. The surface is covered with about 50% of angular to subangular cobbles of rocks. Parts of these soils are orthents, while few parts of slopes are very rich in organic matter and are deeper than its surroundings, possibly mollic epipedon, USDA[11]. At the feet of the slopes, the soils are deeper than one meter with gravelly loam texture, dark in colour, passing into heavily weathered bed rock.

The valley is floored with typical fluvial sediments up to 3 m depth of silty loam to sandy loam, and the soils are mainly fluvents, USDA[11], but in pieces gravelly. The main stream runs through coarse sandy materials.

Soil distribution in Hema Bani Sar shows that ⩾ 50% are rock outcrops, ⩾ 30% orthents, ⩾ 10% fluvents, ⩾ 5% molli-fluvents, ⩾ 5% xerolls and ⩾% Psamments, USDA[11].

In a comparison between soils in- and outside the *hema* (Table 2), it was found that, inside the *hema,* soil is always deeper and this may lead to reduce the proportion of precipitation lost as surface runoff and enable plant roots to penetrate more deeply, reducing the short-term drought. The organic matter content and cation exchange capacity is always higher in soils inside the *hema.* Soils of the same physiographic positions inside and outside the *hema* vary greatly in their texture and gravel contents. Inside the *hema,* soils have less gravel content and are finer in texture. These variations are very apparent because the rocks within the *hema* tend to be more massive than those outside the *hema,* and appear to undergo deep chemical weathering giving a relatively deep and fertile soil. In contrast, the very schistose rocks, which are more common outside the *hema,* undergo mainly physical breakdown giving a regolith composed largely of angular fragments of bedrock caused by severe fluvial erosion due to lack of vegetation. Inside the *hema,* there is always a relatively low proportion of exposed bedrock and soil development on the slopes is likely to be more efficient than outside the *hema* due to the relatively low rate of water erosion.

Hema Bani Sar is a tribal hema in which grazing is strictly prohibited. Its plant cover is a grassland type dominated by *Themeda triandra* with abundant growth of *Juniperus procera* and *J. brachycarpa* trees and shrubs. The other plants recorded in-

TABLE 2. Characteristics of soil samples collected from outside (out) and inside (in) Hema Bani Sar and Hema Thamala, SW Hijaz Mountains, Saudi Arabia.

Characteristics	Hema Bani Sar				Hema Thamala			
	Slopes		Wadi		Slopes		Wadi	
	in	out	in	out	in	out	in	out
Depth	50	20	300	100	20-40	10-30	300	100
Texture								
A Horizon	Gravelly Sandy	Bouldery Sandy	Sandy to silty	Gravelly Sandy	Gravelly Sandy	Bouldery Sandy	Sandy Loam	Sandy Loam
C Horizon	"	"	Sandy	"	"	"	Logmy Sand	Gravelly Sand
Structure								
A Horizon	Coarse Gran.	Fine Gran.	Coarse Gran.	Fine Gran.	Med. Gran.	Med. Gran.	Coarse Gran.	Med. Gran.
C Horizon	Massive	Massive	Subang.	Massive	Massive	Massive	Subang.	Massive
Consistence	Soft, non-sticky	Hard, non-sticky	Hard non-sticky	Soft, non-sticky	Soft, non-sticky	Hard, non-sticky	Hard, non-sticky	Hard, non-sticky
Root contents	many	comm.	many	many	comm.	comm.	many	many
Organic matter of A horizon (%)	0.68–1.95	0.32–0.68	0.84–1.18	0.58–0.86	0.58–0.62	0.46–0.54	0.78–0.98	0.58–0.92
Cation exchange capacity (mg/100 gm soil)	9.8–21.2	5.8–6.4	14.6–19.4	11.2–14.6	9.2–12.6	7.9–10.4	9.6–14.2	7.8–10.8
pH in soil paste	7.2	7.1	7.6	7.4	6.9	7.1	7.4	7.4

clude, shrubs, *e.g. Olea Chrysophylla, Acacia mellifera, Leptadenia pyrotechnica, Dodonae viscosa, Melia azedarch,* ... etc., bushes *e.g. Psiadia arabica* (non-palatable and increasive plant outside the *hema*), *Francoeuria crispa, Lavandula pubescense, Artemisia judaica, Indigofera spinosa, Teucrium polium, Solanum incanum,* ... *etc.*, herbs, *e.g. Indigofera sessilifolia, Osteospermum vaillantii, Reseda pruinosa, Astragalus asterias, Asphodelus fistulosus* v. *tenuifolius, Dianthus strictus, Onobrychis ptolemaica, Onopordom ambigum, Rumex nervosus, Conyza incana, Haplophyllum tuberculatum, Launaea cessiniana,* ... etc., thistles, *e.g. Echinops spinosissimus,* and grasses, *Hyparrhenia hirta, Digitaria nodosa, Tetrapogon villosus, Cymbopogon schoenanthus,* Brachiaria ramosa, Aristida adscensionis, Phalaris minor, Eragrostis ciliaris, Cynodon dactylon,* ... etc. In the shady areas of the rock slopes and in the rock crevices, there are moist loving ferns, *e.g. Cheilanthus fragransa, C. catanensis* and *Asplenium trichomanes* grow.

Density of plant cover varies greatly inside and outside the *hema*. Two quadrats (10 × 10 m each) have been set up, one inside and the second outside the *hema*. The plants are counted and/or measured** (Table 3). It is obvious that the plant cover of

TABLE 3. Number and cover of plant species in two quadrats (10 × 10 m each) inside and outside *Hema Bani Sar*, Saudi Arabian, Hijaz Mountains.

Species	Inside the Hema		Outside the Hema	
	N	C	N	C
Themeda triandra	–	75.0	–	10.04
Juniperus procera	8	12.3	1	1.5
Hyparrhenia hirta	–	1.89	0.0	0.0
Dodonaea viscosa	3	0.65	2	3.24
Francoeuria crispa	5	0.62	5	1.63
Artemisia judaica	2	0.28	3	0.73
Psiadia arabica	4	1.49	33	22.7
Cymbopogon schoenanthus	–	13.4	–	4.9
Total plant cover (m^2)		95.63		44.74

N = Number of Individuals C = cover (m^2)

the dominant grass *Themeda triandra* inside the *hema* (quadrate 1) is greater (75%) than outside it (10.04%). The thick growth of *T. triandra* inside the *hema* gives little room for the other associate species, except *Juniperus procera* shrubs, to grow freely. *Psiadia arabica*, which is the dominant on the slopes outside the *hema*, is represented in this quadrat (inside) by only 4 individuals with very low plant cover (1.49 m^2). Outside the *hema*, the effect of free grazing is clear (Table 3). The plant cover is generally low (44.74%) as compared to the total plant cover of the quadrat inside (95.63%). *Psiadia arabica* (non-palatable) predominates (33 individuals and 22.7% cover). *Themeda triandra*, on the other hand, is severely grazed, only its rhizomes are seen. In the quadrat outside the *hema*, the cover of the non-palatable plant is relatively higher than in the quadrate inside.

2. *Hema Thamala*

Hema Thamala lies about 20 km east of Taif city. It occupies the catchment areas of four wadis with an area of 7 km^2. It is a deeply dissected area of precambrian igneous rocks with a relative relief of about 34.8 m. A large part of the slopes are covered with an estimated 50-100 cm of loamy sand and sandy loam soils usually gravelly with a cover of cobbles on the surface.

The *hemma* channel contains several meters of sandy loam and loamy sand, while the adjacent erosional terraces are formed of cobbles in a loamy and matrix. The channel is extensively wide, and the slopes are ranging between 20-25°.

*Non-palatable grass as it contains non-volatile oils, Aynesu[18].

**For grasses we measured the area they cover.

The distribution of soils in this *hema* shows that ⩽ 50% are rock outcrops, ⩾ 30% orthents, mainly on the slopes and some on the terraces, and ⩾ 20% fluvents, mainly in the excessively wide erosional terraces (Table 2).

Hema Thamala, like *Hema Bani Sar,* is a tribal one. Its four branches drain eastward into Al Sana eel village. The northern branch is called Al-Musaiel Al-Saghir (denoting the small drain) followed southward with Al-Musaiel Al-Kabir (denoting the large drain) from which Al-Habga branch originates. The southern branch is called Dalala (Fig. 2).

The Al-Musaiel Al-Saghir, *Psiadia arabica* is the dominant plant both in the main stream of the Wadi and on the lower zones of the side slopes as well. *Argemone mexicana* is the most abundant associate species in the downstream part of the wadi, where soil is formed mainly of coarse and fine sands. In the rocky areas, *A. mexicana* disappears. The other associate species that are commonly present with *P. arabica* include *Fagonia cretica, Zizyphus spina-christi, Echinops spinosissimus, Lavandula pubescense, Blepharis ciliaris, Asphodelus fistulosus* v. *tenuifolius, Salsola tetranda* (rare), *Francoeuria crispa* (abundant), *Cynodon dactylon, Calotropis procera* (one individual), *Astraglus asterias, Lycium shawii, Gomphocarpos sinaicus, Indigofera spinosa, Olea chrysophylla, Launuaea* sp., *Malva parviflora, Melilotus alba, Dodonaea viscosa, Rhamnus staddo* v. *deflersii, Ferula sinaica, Artemisia herba-alba, Conyza dioscorides* (rare), *Ficus salicifolia, F. pseudosycomorus, Ochradenus baccatus, Euphorbia nubica* (new record to the flora of Saudi Arabia), ... etc.

The density of *P. arabica* decreases gradually in the higher zones of the slopes, and grasses start to take its place. *Hyparrhenia hirta* predominates on the high altitudes of both slopes. The associate grasses include *Themeda triandra, Pennisetum setaceum, Polypogon monspeliensis, Brachiaria leersioides, B. ramosa, Paspalidium geminatum, Dactyloctenium aegyptium,* ... etc.

The moist loving plants, *e.g. Cyperus* spp. *Juncus* spp., ... etc., usually grow in the wet areas at the feet of the slopes. The succulent xerophytes, *e.g. Caralluma penicillata, Euphorbia* spp., are commonly present on the slopes.

Al-Musaiel Al-Kabir represents the main branch of *Hema Thamala.* It is also dominated by *Psiadia arabica* in the water stream of the wadi and on the lower zones of the slopes. It is associated with the following species, *Gomphocarpus sinaicus, Blepharis ciliaris* (abundant), *Ficus salicifolia, F. pseudosycomorus, Olea chrysophylla, Cynodon dactylon, Ochradenus baccatus, Zizyphus spina-christi, Echium sericeum, Argemone mexicana, Alcea acaulis, Rhamnus staddo, Eragrostis ciliaris, Euphorbia nubica, E. granulata, Dodonaea viscosa, Abutilon fruticosum, Periploca aphylla, Peganum harmala, Lycium shawii, Helianthemum sessiliflorum, Solanum albicaule, Artemisia herba-alba, Asphodelus fistulosus* v. *tenuifolius, Trifolium procumbens, Rumex vesicarius, Senecio desfontaine, Verbena officinalis, Matthiola humilis, Koelpinia linearis, Atractylis carduus, Helichrysum somalense, Celosia trigyna, Lavandula pubescense, Melilotus alba, Linaria haeleva, Ferula sinaica, Salvadora persica,* ... etc.

The terraces of the main stream of this branch are formed mainly of compact sand deposits. These terraces are suitable habitat for the domination of *Francoeuria crispa* (unpalatable) which establish its own society. *Psiadia arabica,* though dominant in the near rocky areas, yet it is rare in these societies. *Blepharis ciliaris* is the most abundant associate species. *Solanum albicaule* and *Rhamnus staddo* (heavily grazed) are occasionally present.

Predomination of *Psiadia arabica* continues in the midstream and upstream parts of the wadi. Individuals of *P. arabica* in these parts of the wadi have vigorous growth form than those of the downstream part.

Thick vegetation of trees and shrubs of *Olea chrysophylla, Zizyphus spina-christi* and *Salix subserrata* characterise the narrow upstream part of this branch.

Grasses are rich on the higher altitudes of the slopes of this branch. *Hyparrhenia hirta* predominates. The other grasses include *Themeda nodosa, Cenchrus ciliaris, Lasiurus hirsutus, Digitaria nodosa, Pennisetum setaceum, Polypogon monspeliensis,* ... etc. Lawns of *Cynodon dactylon* (heavily grazed by local cows) and other annual grasses are common at the feet of the slopes where soil is highly moistened.

In Al-Habga branch, *Psiadia arabica* is dominant both on the slopes and in the main stream of the wadi. The associate species are almost comparable to those of Al-Musaiel Al-Kabir. In the upstream part of Al-Habga, the stream gets narrow and the two slopes are very near. The main stream is blocked with thick vegetation dominated by *Olea chrysophylla* trees. The associate species are *Periploca aphylla, Zizyphus spina-christi, Dodonaea viscosa, Rhamnus staddo, Francoeuria crispa, Launaea nudicaulis, Lavandula pubescense, L. stricta, Solanum albicaule, Bromus* sp., *Psiadia arabica,* ... etc. In this part of the wadi, the low zones of the slopes are dominated by *Psiadia arabica.* Grasses, on the other hand, are abundant on the higher levels far from the reach of the cows. This indicates how far the grazing effect has its bad impress on the plants, especially the highly palatable grasses, which escape to the unreached hardy high slopes to predominate. The unpalatable *Psiadia arabica* plants replace the grasses in the lower zones. The rhizomes of these grasses have been seen on the lower zones. The most abundant grass is *Hyparrhenia hirta* with *Themeda triandra* (abundant), *Stipagrostis* sp. (common) *Avena* sp, ... etc. *Dodonaea viscosa* is very common on these slopes and its individuals are increasing in number and vigour on the higher levels.

Like in Al-Musaiel Al-Kabir, *Francoeuria crispa* predominates on the terraces formed of compact sand mixed with gravels. In these societies, *Blepharis ciliaris* is the abundant associate species.

In Dalala branch, the plant cover does not vary greatly from that of Al-Habga. *Psiadia arabica,* is the dominant in the main stream and on the lower zones of the slopes, and grasses are very abundant on the higher zones of the slopes. In this branch and at the feet of the slopes, there are saline patches dominated by *Aeluropus* spp.

Representative areas of the slopes inside and outside the *hema* were selected to carry out a quantitative study of the grazing effects of plant cover. Two quadrats (10

× 10 m each) were set up on the slopes of Al-Musaiel Al-Kabir branch: the first represented the plant cover of a steep slope which cannot be climbed by cows, and the second was located at the base of a gentle slope easily reached by cows. A third quadrat was set up on a non-protected slope outside the *hema* where grazing was free for all livestock. In each quadrat, plants were counted and/or their covers were measured (for grasses, their covers only were measured). The results given in Table 4

TABLE 4. Number and cover of plant species of three quadrats (10 × 10 each) inside and outside *Hema Thamala,* Saudi Arabian Hijaz mountains.

Species	Inside the *Hema*				Outside the *Hema*	
	Quadrat 1		Quadrat 2		Quadrat 3	
	N	C	N	C	N	C
Hyparrhenia hirta	–	48.13	–	11.74	–	7.25
Psiadia arabica	15	6.44	36	29.63	0.0	0.0
Indigofera spinosa	0.0	0.0	7.0	4.69	34	19.65
Linaria haeleva	12	2.65	0.0	0.0	0.0	0.0
Ferula sinaica	2	0.1	0.0	0.0	0.0	0.0
Trifolium procumbens	1	0.12	0.0	0.0	0.0	0.0
Matthiola humilis	1	0.48	0.0	0.0	0.0	0.0
Avena fatua	–	0.1	0.0	0.0	0.0	0.0
Themeda triandra	–	0.1	0.0	0.0	0.0	0.0
Francoeuria crispa	0.0	0.0	2	0.18	0.0	0.0
Launea sp.	0.0	0.0	1	0.05	0.0	0.0
Echinops spinosissimus	0.0	0.0	1	0.05	0.0	0.0
Dodonaea viscosa	0.0	0.0	1	0.72	0.0	0.0
Blepharis ciliaris	15	0.3	100	2.00	30	0.6
Fagonia cretica	0.0	0.0	0.0	0.0	12	0.32
Lycium shawii	0.0	0.0	0.0	0.0	15	8.84
Cassia senna	0.0	0.0	3	0.6	0.0	0.0
Dodonaea viscosa	0.0	0.0	1	0.2	0.0	0.0
Solanum incanum	1	0.2	0.0	0.0	1	0.3
Fagonia arabica	0.0	0.0	0.0	0.0	6	0.8
Tephrosia purpurea	2	0.2	0.0	0.0	0.0	0.0
Total plant cover (m^2)		56.82		49.96		37.76

N = Number of individuals C = Cover (m^2)

show that *Hyparrhenia hirta* is the most common grass both outside and inside the *hema.* It is, actually, the main grass upon which livestock depend for grazing in the area. Grazing effect was very obvious and its impress on plants could be detected easily. Inside the *hema, H. hirta* predominates on the steep hard slope (quadrat 1, cover = 48.13%), *i.e.* the area is protected naturally against cow grazing. *Psiadia arabica* (cover = 6.44%) and *Linaria haeleva* (cover = 2.65%) are the common associate species. In quadrat 2 inside the *hema,* where cows can graze, *P. arabica,* which is unpalatable shrub, is the dominant plant (cover = 29.63%). No aerial parts of grasses were seen, only rhizomes of *H. hirta* where measured and found to cover about 11.74% of the quadrat. In this quadrat, *Indigofera spinosa* (spiny bush eaten by sheep only) is a common associate (cover = 4.69%). Many individuals of the thistle plant *(Blepharis ciliaris)* were recorded, it is not eaten by camels.

The picture of plant cover outside the *hema* (quadrat 3) is widely different. The slopes are dominated by overgrazed individuals of *Indigofera spinosa* (cover = 19.65%). *Lycium shawii,* spiny solanaceae shrub, is the most common associate plant (cover = 8.84%). The grasses, on the other hand, are represented only by thin rhizomes, all of the aerial parts are grazed. The total plant cover inside the *hema* (56.82% and 49.9%, on the high and slow slopes, respectively) are higher than that outside the *hema* (37.7%).

3. *Hema Sakhayet*

This *hema* lies about 16.5 km southeast of Taif occupying the upper part of a relatively small drainage system. Its boundaries to the east, south and west being defined by the drainage basin watershed. It is approximately 4 km long and 1 km wide and covers 4 km^2.

The area of *Hema Sakhayet* is one of deeply dissected precambrian rocks with a relative relief of about 485 m. Slope angles vary considerably, but are typically 15-30°, steeper locally, although the summits are generally rather more level (typically 10-20°)? There is a proportion of exposed bedrock (about 30% of the ground surface), and in these areas sandy loam soil is present only in joints and fissures. The remainder of the slopes are covered with 30-100 cm of gravelly loamy sand and gravelly sand loam soil (Pssaments and Orthents association[12], The minor water courses are filled with an estimated 0.5 m depth of cobbly, silty and gravelly sand. They are usually not heavily vegetated.

The main course of *Hema Sakhayet* is floored with several meters of sandy loam and loamy sand soils; gravelly in places. These deposits are flanked by erosional terraces formed by the downslope movement of weathered material. The terraces are formed of fine to coarse cobbles, subangular to rounded set in a sandy loam to loamy sand matrix. They are generally extensive up to 45 m wide where fluvents occur with a depth of more than 70 cm, having silty to sandy loam texture.

No clear apparent difference was observed between the *hema* and those of surrounding areas relative to that noticed at *Hema Bani Sar.*

Five community types have been recognized in the main stream and the slope of *Hema Sakhayet,* namely :

(1) *Conyza dioscorides* Community type.
(2) *Psiadia arabica* Community type.
(3) *Francoeuria crispa* Community type.
(4) *Euphorbia nubica* Community type.
(5) Grasses.

Conyza dioscorides (eaten only by camels) predominates in the main stream and its domination continues upwards in the wadi. In the downstream part, the soil is loose and formed of mixed sands, the plant cover is relatively higher and the floristic composition includes *Argemone mexicana* (abundant), *Francoeuria crispa* (abundant), *Lycium shawii, Helianthemum* sp., *Echinops spinossimus, Pancratium sickenbergeri, Ochradenus baccatus, Cynodon dactylon, Psiadia arabica,* ... etc. *Argemone*

mexicana disappears when the substratum changes to be rocky.

Plant cover of the slopes of *Hema Sakhayet* is zonated into 3 altitudinal zones: *Francoeuria crispa* zone, *Psiadia arabica* zone, and *Euphoria nubica* zone.

Francoeuria crispa predominates in the lower zone and its associate species include *Psiadia arabica, Echinops spinosissimus, Aizoon canariense, Monsonia nivea, Centauraea sinaica, Asphodelus fistulosus* v. *tenuifolius, Cynodon dactylon, Peganum harmala, Malva parviflora, Heliotropium* sp., *Solanum incanum, Acacia tortilis* (rare) *Blephalis ciliaris, Indigofera spinosa, Euphorbia nubica,* ... etc.

The middle zones are dominated by *Psiadia arabica* which is associated with *Helianthemum* sp., *Blephalis ciliaris, Paspalidium geninatum, Francoeuria crispa* (abundant, eaten by camels only), *Solanum incanum, Cynodon dactylon, Fagonia bruguieri, Aizoon canariense, Solnum dubium, Monsonia nivea, Indigofera spinosa, Launea* sp., *Echinops spinosissimus, Arnebia hispidissima, Trigonella* sp., *Salvia aegyptiaca, Cassia* sp., *Ifloga spicata, Plantago* sp., *Abutillon fruticosum, Caralluma retrospiciens* (it is called in Arabic Zibdet Al-Kalb *i.e.* the Butter of the Dog, it is eaten by dogs), ... etc.

In the high altitude of the east facing slope, *Euphorbia nubica* is very abundant. Grasses are well developed and include *Hyparrhenia hirta* (dominant), *Themeda triandra, Hordeum leporinum, Avena fatua, Cynodon dactylon* and *Tetrapogon spathaceae.* The other associates are *Indigofera spinosa, Psiadia arabica, Centaurea* sp., *Rumex vesicarius, Aizoon canariense, Lavandula pubescense, Caralluma siraica, Otostegia fruticosa* v. *schimperi, Fagonia cretica, Francoeuria crispa, Lycium shawii, Linaria haelava, Cocculus pendulus, Aloe vera, Lantena salvifolia,* ... etc. Density of plants, especially grasses, increases considerably on the higher levels of the slopes, which cannot be reached by cows.

The plant cover inside (protected) and outside (non-protected) the *hema* had been studied quantitatively using the quadrat method. The plants of two quadrats (10 × 10 m each) inside the *hema* and one outside it were counted and/or measured. Variation of plant cover was quite obvious (Table 5). In the upper zones inside the *hema,* the highly palatable plants, *e.g. H. hirta,* are the most abundant (plant cover = 43.50%), the lower zones are dominated by the non-palatable shrubs, *Psiadia arabica* with a cover up to 25.5% of the quadrat. The cover of *H. hirta* in this zone, which is easily reached by cows, is reduced to 11.5%. Outside the *hema,* the picture is completely different due to free grazing. The ill-representation of grasses (*H. hirta* cover = 4.9%, only rhizomes) give the chance to *Indigofera spinosa*) to predominate (plant cover = 17.2%). The total plant cover is also affected by the degree of grazing. In the higher zones (quadrat 1, Table 5) inside the *hema* (where cows are the only animals allowed to graze), the total plant cover is high (744 m^2) mainly grasses (48.9%), no single individual of *I. spinosa* was recorded. Cows cannot climb up to that zone. In the lower zones (quadrat 2) easily accessible by cows, the total cover is reduced to 45.9%, mainly by *Psiadia arabica* (25.5%) which is a non-palatable bush, the cover of grasses is reduced to 13.1%. In this quadrat, eight individuals of *I. spinosa* were recorded, but their cover was negligible (2.9%). In quadrat 3 (outside the *hema*) where

TABLE 5. Number and cover of plant species of three quadrats (10 × 10 each) inside and outside *Hema Sakhayet*, Saudi Arabian Hijaz mountains.

Species	Inside the *Hema*				Outside the *Hema*	
	Quadrat 1		Quadrat 2		Quadrat 3	
	N	C	N	C	N	C
Hyparrhenia hirta	–	43.5	–	11.5	–	4.9
Psiadia arabica	20.0	6.0	37.0	25.5	1.0	0.2
Indigofera spinosa	0.0	0.0	8.0	2.9	35	7.2
Otostegia fruticosa	4.0	1.7	2.0	1.6	4	4.2
Artemisia judaica	4.0	0.8	3.0	0.10	4	0.8
Fagonia arabica	3.0	0.4	2.0	0.2	5	0.5
Blepharis ciliaris	35.0	5.5	33.0	3.0	50	6.0
Calligonum comosum	–	2.0	0.9	0.0	0.0	0.0
Ochradenus baccatus	1.0	0.2	5.0	2.5	1.0	0.2
Lycium shawii	0.0	0.0	0.0	0.0	12	1.2
Hordeum leporinum	–	2.4	–	0.8	0.0	0.0
Avena fatua	–	2.0	–	0.5	0.0	0.0
Tetrapogon spathaceus	–	1.0	–	0.3	0.0	0.0
Total plant cover (m^2)		74.4		45.9		35.2

N = Number of individuals C = Cover (m^2)

grazing is free for all livestock, the total plant cover was reduced to 35.2%, mainly contributed by *I. spinosa* (17.2%) stunted individuals. The cover of the grasses is reduced to 4.9% (mainly rhizomes of *H. hirta*). *P. arabica* is represented with only one individual.

Livestock

The only type of domestic animals allowed to graze inside, *Hema Thamela* and *Hema Sakhayet* is the cattle. These are the indigenous zebu type and belong to the *Tihama* breed. They have very short horns and the characteristic zebu hump on the withers. Although they are relatively small in size, yet many of them tend to have strong bodies, especially the neck and forequarters, as the breed was developed mainly for work in ploughing in the fields. Some examples of well-developed udders indicate the potentialities of the breed of milk production[8].

Cattle grazing inside these two *hemmas* is free and unattended. The grazing behaviour of cattle is much affected by the topography. They have developed grazing routes in the easily accessible areas, which include the eroded terraces and the lower gentle slopes inside the *hemmas*. They tend to avoid, as much as possible, the loose sand in wadi bottoms and the sharp elevated or steep rocky areas.

Cattle seem to prefer grasses for grazing. These include the tall grasses, *e.g. Hyparrhania hirta, Themeda Triandra,* ... etc., on the slopes and the lawn grass, *e.g. Cynodon dactylon,* on the erosional terraces, which seem to be cherished by cattle.

The wild olive trees *(Olea chrysophylla)* as well as trees of *Rhamnus staddo* are

also browsed by cattle. Heavy browsing along the cattle tracks has caused stunting of growth and excessive branching of some of these trees.

Outside these two *hemas,* free-grazing areas left for sheep and goats, but cattle seem not to encounter grazing in these poor areas.

Discussion and Conclusion

The three studied *hemas* are areas of deeply dissected precambrian rocks (schists and igneous intrustives) with relatively shallow soils and geomorphologically are very similar, although the slopes of *Hema Bani Sar* are typically less steep than those of *Thamala* and *Sakhayet hemas.* From the results obtained, it may be concluded that *Hema Bani Sar* has shown advantages compared to the other two *hemas* regarding vegetation density and soil conditions. This may be attributed to the type of protection prevailing in each *hema.* As previously mentioned, *Hema Bani Sar* has long been protected from sheep or cattle grazing, while in the other two *hemas,* the cattle are allowed to graze freely within their boundaries. In addition, more recently the ban on grazing by sheep appears to have been very considerably relaxed.

Hema Bani Sar has been under strict protection, therefore the increased growth of choice grazing plants has reduced. The growth of undesirable vegetation and high producing grasses now dominate the landscape. The plant cover outside the *hema* is composed of heavily grazed grasses (only rhizomes can be seen), and large number of non-palatable plants.

In *Hema Thamala* and *Hema Sakhayet,* dominations in the main water streams and on the lower zones of the slope are for the non-palatable shrubs; grasses and other palatable plants are either rare or absent. The higher zones of the slopes non-reached by livestock are rich in grasses.

Resultant denudation of the plant cover in these range reserves led to serious soil erosion associated with frequent destructive floods. Erodibility of soils, outside and inside the *hemas,* varies greatly, especially for *Hema Bani Sar.* It was measured through measuring soil properties, reduced transportability as well as reducing runoff hazard.

The quantitative measurements of the vegetation as well as the detailed analyses of the soil types in- and outside the three *Ahmia* of the present work are new contributions to our understanding about the ecology of the *Hema* System of Saudi Arabia. In fact, similar studies seems to be essential, for the other *Ahmia* of the montane country of Saudi Arabia.

Acknowledgement

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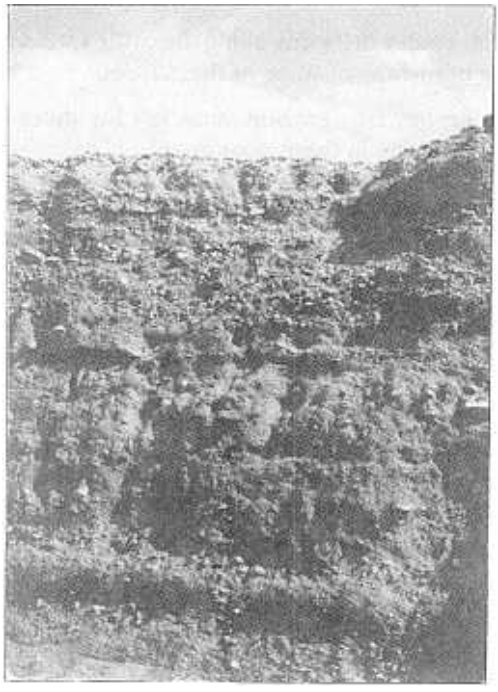

Photo 1: Deep soil profile inside Hema Bani Sar.

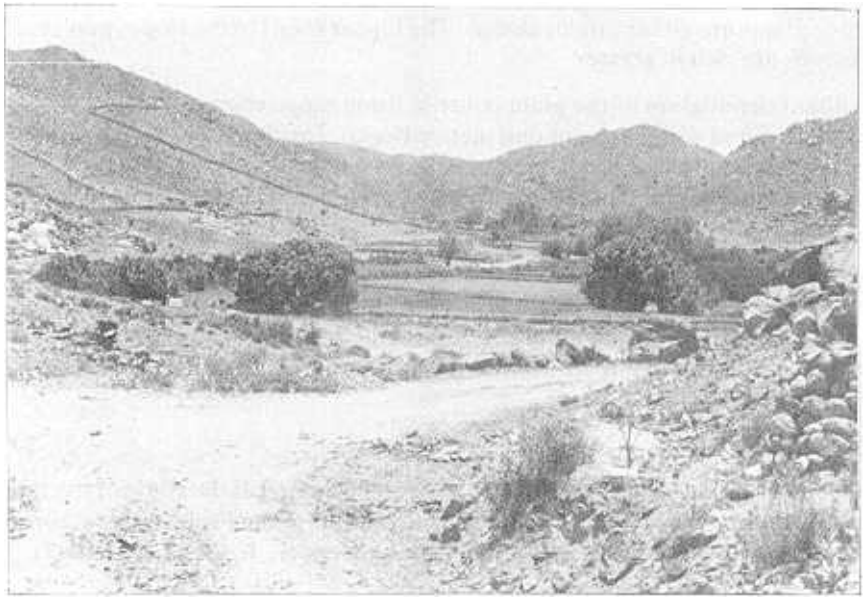

Photo 2: General view of an individual *hema* (Hema Al-Hoghrah) fenced with stone walls on one of the slopes of Taif mountains. Notice the cultivated lands at the foot of the hill.

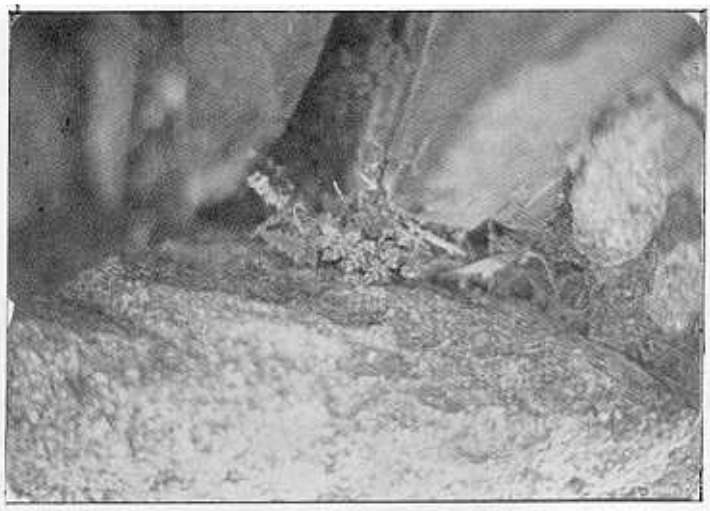

Photo 4

Photo 3

Photo 5

Photo 3-5: Moist loving plants growing in the shady rocky habitats of Hema Bani Sar.

Photo 6: General view of Hema Sakhayet of Taif mountains.

Photo 7: Stunted *Olea chrysophylla* shrubs due to browsing by cattle in Hema Thamala.

Photo 8: Cows drinking from an artificial pool dug in Hema Thamala.

Photo 9: Lower zone of a slope inside Hema Thamala where the non-palatable plants *e.g. Psiadia arabica* are abundantly growing.

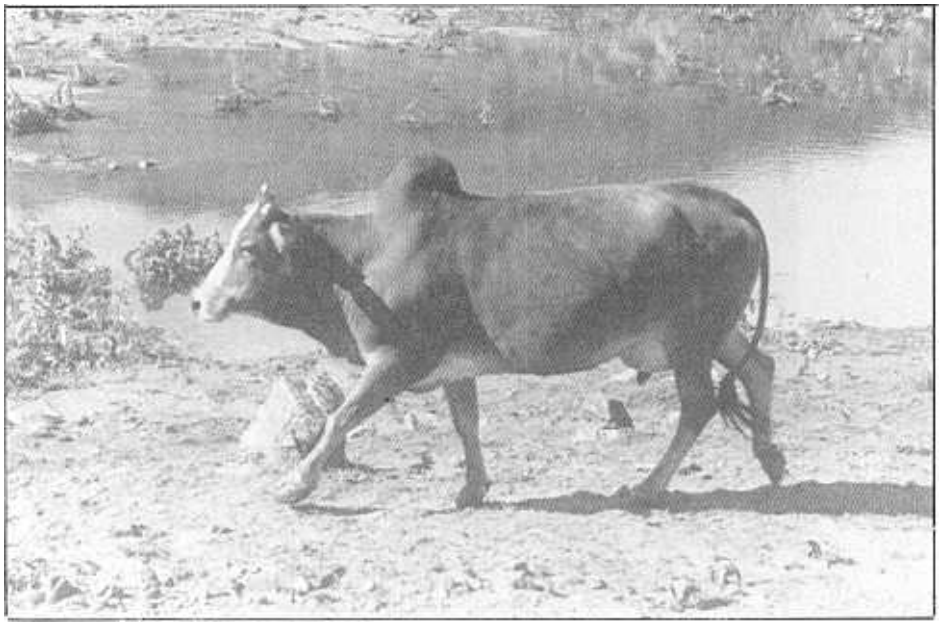

Photo 10: A good Tihama Cow malking in Hema Thamala.

Photo 11: Grass dominating the steep upper slopes of Hema Thamala.

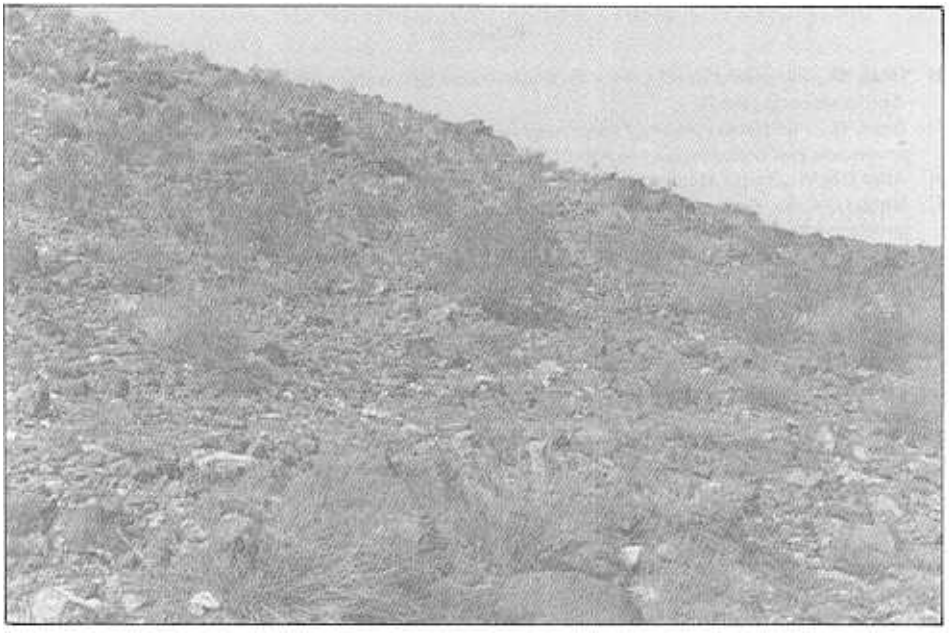

Photo 12: Domination of *Psiadia arabica* (non-palatable) on the slopes inside Hema Thamala.

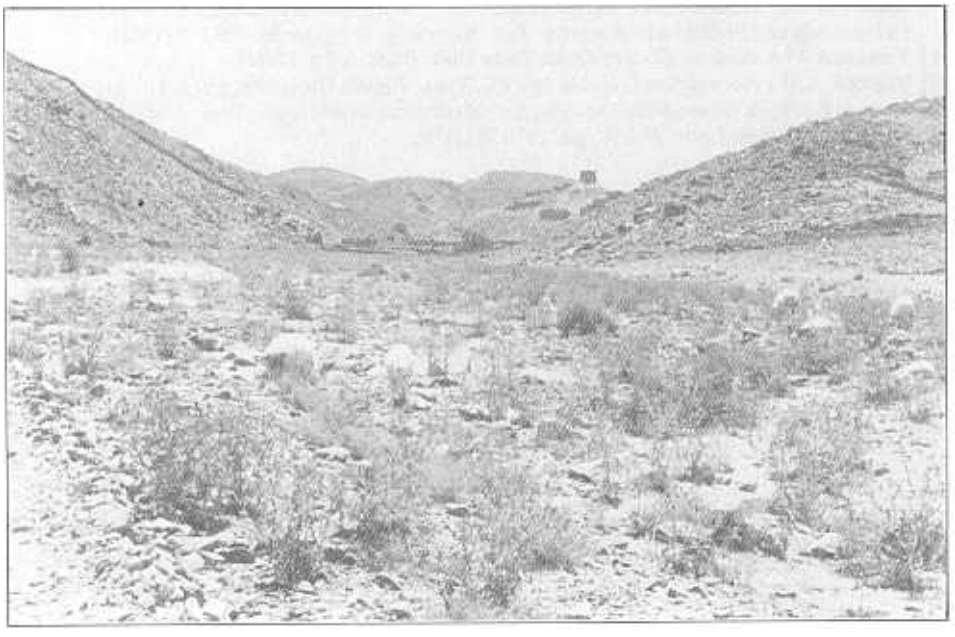

Photo 13: General view of the water course of Wadi Thamala (outside the Hema) dominated by the non-palatable plant *Argemone mexicana)*. Sheep are grazing grasses only.

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الأحمية كنـظام تقليدي للحفـاظ على الحياة النباتية بالمملكة العربية السعودية

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منذ زمن بعيد وقبل العصر الإسلامي ونظام الأحمية للحفاظ على الحياة النباتية يجري بنجاح بالمنـاطق الجبلية جنوب غرب المملكة العربية السعودية بناء على قواعد وقوانين قبلية غير مدونة ولكنها تحترم بدقة وتنفذ بحزم بين رجال القبائل في هذه المناطق الجبلية .

ولأهمية الأحمية كنظام فطري ، أجرى الباحثان دراسات إيكولوجية على الغطاء النباتي والتربة داخل وخارج ثلاثة أحمية ، هى حِمى بني سار ، حِمى ثمالة وحِمى سخايط ، كمثل لأحمية المنطقة (التي يصل عددها إلى ٢٠٠ حِمًى) . أوضحت نتائج الدراسات مدى التأثير السيء الـذي يُحدثه الرعي الجائر خارج الأحمية عنه في داخلها ، حيث الرعي ممنوع . ولوحظ كذلك أنه في الأحمية التي يُسمح فيها بدخول بعض الحيوانات (البقر) ومنع بعضها الآخر (المـاعز والخراف) ، تقل كثيراً كميات النباتات الصالحة للرعي (أغلبها نجيليات) ، وخـاصـة النـامية على المنحدرات المنخفضة التي يسهل على البقر الصعود إليها ، وتزداد كثافتها على المنحدرات العالية البعيدة عن متناول الأبقار . كما أوضحت الدراسة كذلك أن التربة داخل الأحمية تكون عميقة ، وتحتوى على كميات كبيرة من المواد العضوية والمعادن عنـه في التربة خارج الأحمية التي تتعرض بشدة لعوامل التعرية نتيجة لخلوها من الغطاء النباتي الذي يحمى التربة داخل الأحمية .

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