PN-ABC-782

AGRICULTURAL RESEARCH CORPORATION

WESTERN SUDAN AGRICULTURAL RESEARCH PROJECT

# RANGE/LIVESTOCK RESEARCH ACTIVITIES

# 1982/1983

WSARP PUBLICATION No. 29

AUGUST 1984

AGRICULTURAL RESEARCH CORPORATION

WESTERN SUDAN AGRICULTURAL RESEARCH PROJECT

THE GOVERNMENT OF SUDAN

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

THE WORLD BANK

CONSORTIUM FOR INTERNATIONAL DEVELOPMENT

WASHINGTON STATE UNIVERSITY

# RANGE/LIVESTOCK RESEARCH ACTIVITIES

1982-1983


W. T. BUNDERSON, PH.D. — RANGE ECOLOGIST

R. H. COOK, D.V.M., PH.D. — LIVESTOCK PRODUCTIONIST

B. FADLALLA, PH.D. — ANIMAL NUTRITIONIST



WSARP PUBLICATION No. 29

AUGUST 1984

THE WESTERN SUDAN AGRICULTURAL RESEARCH PROJECT

is supported by

The Government of Sudan

The Agricultural Research Corporation

US Agency for International Development

The World Bank

The USAID portion of the project is being implemented by

The Consortium for International Development
Tucson, Arizona, USA

with

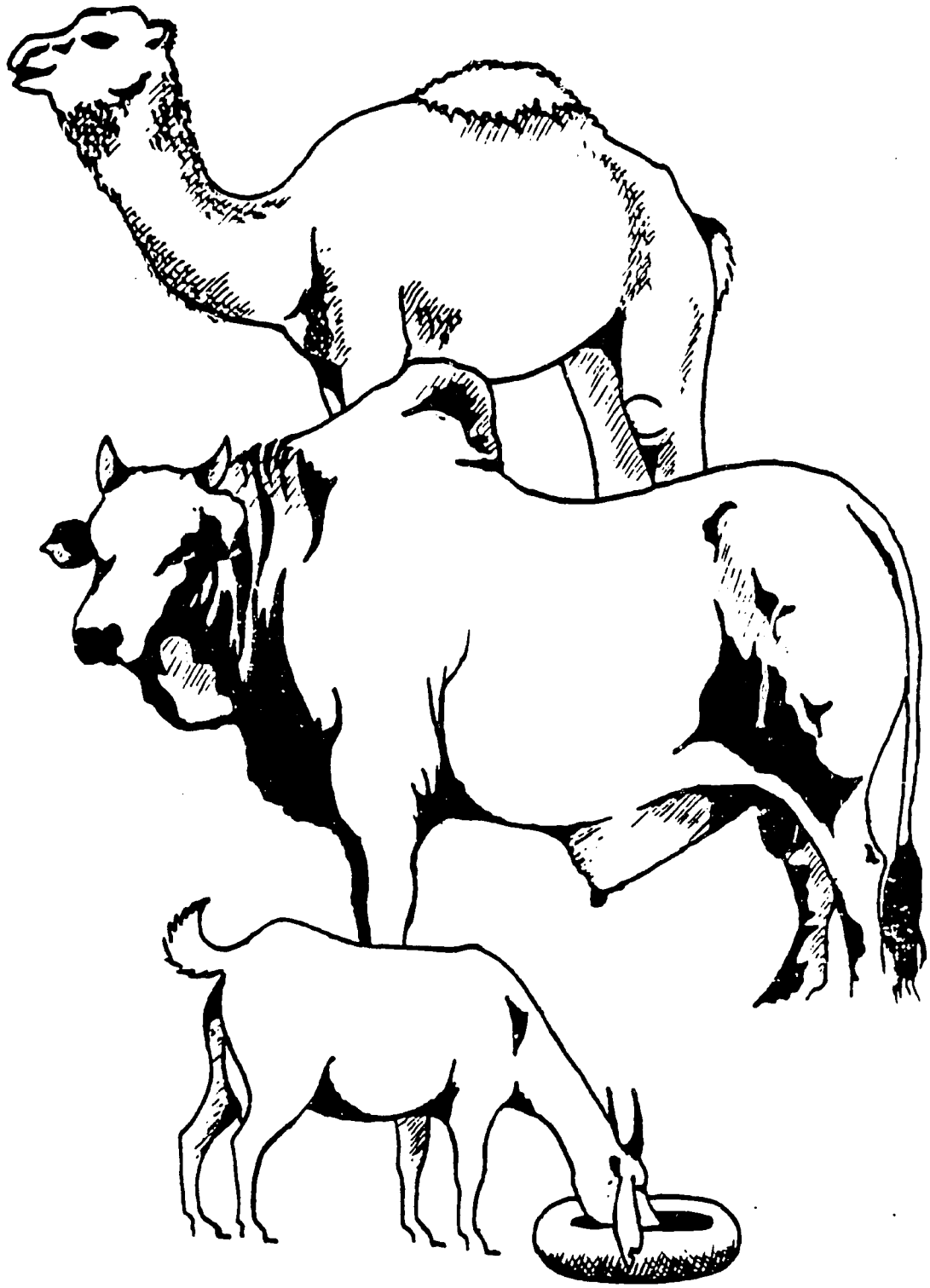
Washington State University, Pullman, Washington, USA

as the Lead University

Correct Citation:

WESTERN SUDAN AGRICULTURAL RESEARCH PROJECT

Kadugli Research Station
Range/Livestock Research Activities 1982/1983
WSARP Publication No. 29
Khartoum, Sudan and Pullman, Washington, USA



# KADUGLI RESEARCH STATION
# RANGE/LIVESTOCK
# RESEARCH ACTIVITIES
# 1982 & 1983

W.S.A.R.P

# RANGE/LIVESTOCK RESEARCH ACTIVITIES

1982-1983

by

W. T. Bunderson, Ph.D.
Range Ecologist

B. Fadlalla, Ph.D.
Animal Nutritionist

R. H. Cook, D.V.M., Ph.D.
Livestock Productionist

Technical Support Staff

Ahmed Hashim, Senior Technician, Animal Health/Production
Ahmed Salah Ombadi, Senior Technician, Range Science
Adam Mohamed Ali, Senior Technician, Animal Production

Mohamed Suliman, Junior Technician, Animal Production
Ali Sheikh E'Dein, Junior Technician, Range Science
Abdullah Fadl El Mullah, Junior Technician, Animal Production

TABLE OF CONTENTS


| | | Page |
|---|---|---|
| I. | INTRODUCTION | 1 |
| | Sudan | 1 |
| | Research Strategy | 7 |
| II. | CHARACTERISTICS OF THE PHYSICAL ENVIRONMENT IN SOUTH KORDOFAN | |
| | Climate | 9 |
| | Geology | 10 |
| | Drainage Patterns | 11 |
| | Water Resources | 11 |
| | Soils | 12 |
| | Nuba Mountain Soils | 13 |
| | Soils in the Northern Regions of South Kordofan | 16 |
| | Soils South of the Nuba Mountains | 17 |
| III. | RANGELAND RESOURCES IN SOUTH KORDOFAN | |
| | Collection and Identification of Plants | 18 |
| | Rangeland Classification and Mapping | 19 |
| | Rangeland Evaluation | 19 |
| | Herbaceous Vegetation | 20 |
| | Herbage Productivity | 23 |
| | Woody Vegetation | 28 |
| | Factors Influencing Range Condition and Livestock Carrying Capacities | 30 |




F 05

Table of Contents (Continued)

Page

IV. LIVESTOCK RESOURCES IN SOUTH KORDOFAN

Importance to the Region..... 37

Livestock Husbandry and Productivity..... 37

V. BAGGARA TRANSHUMANT SYSTEM

Introduction..... 39

System Characteristics
Factors Associated with Migration..... 39

Patterns of Resource Use During Migrations..... 41

Grazing Patterns in South Kordofan..... 43

Herd Composition and Productivity of Cattle..... 43

The Seasonal Aspects of Productivity in a Migratory and a Sedentary Sentinel Herd..... 47

Seasonal Impact of Disease on Cattle Productivity in South Kordofan..... 53

The Nutritional Status of Cattle Grazing on Cracking Clay Soils..... 63

VI. THE NUBA SEDENTARY SYSTEM

Introduction..... 65

System Characteristics..... 67

Crop Production..... 69

Livestock Production and Patterns of Resource Utilization..... 70

Constraints to Production..... 73

Table of Contents (Continued)

Page

Establishment of a Research Program..... 73

Rangeland Deterioration..... 76

Inefficient Resource Utilization..... 76

Water Availability..... 78

Forage Evaluation Trials..... 78

On-Station Trials..... 78

On-Farm Trials..... 87

Overall Conclusions..... 87

Forage Conservation for Supplementing Cattle - a Farmer-Managed In-Herd Trial..... 88

The Sedentary Group..... 89

The Transhumant Group..... 91

Conclusions..... 92

Feeding Crop Residues and Cut-Native Hay to Cattle During the Dry Season..... 92

Introduction of Animal Draft..... 97

VII. NOMADIC PRODUCTION SYSTEMS

Introduction..... 98

System(s) Characteristics..... 99

Nataural Resource Base..... 100

Socio-Economic Resource Base..... 100

Cropping Component..... 102

Livestock Component..... 103

Market Component..... 106

Constraints to Production..... 107

Future Activities..... 107

Table of Contents (Continued)

Page

VIII. ADDITIONAL ACTIVITIES CONDUCTED IN 1983

Meetings, Conferences, and Workshops..... 108

Consultancies and Linkages with Other Projects..... 109

Publications..... 110

XI. REFERENCES..... 111

X. APPENDIX..... 115

## LIST OF TABLES


| | | Page |
|---|---|---|
| 1. | Characteristics of Eco-Climatic Zones in Sudan | 4 |
| 2. | Changes in Herbaceous Cover, Composition, and Productivity under Protection from Fire and/or Grazing | 24 |
| 3. | Herbaceous Vegetation Changes Monitored from Permanent Transects in Unprotected Sites | 25 |
| 4. | Herbaceous Vegetation Change Under an Early Dry-Season Burning Regime | 25 |
| 5. | Comparison of Herbaceous Composition on a Jebel Hillside: Grazing and No Burning v.s. Burning and No Grazing | 25 |
| 6. | Livestock Biomass and Food Requirements on an Annual Basis in Relation to Net Primary Production, Central Districts, South Kordofan | 31 |
| 7. | Herd sizes and Composition of Baggara Transhumant Cattle by Household | 44 |
| 8. | Composition and Productivity of Hawazma Transhumant Cattle | 45 |
| 9. | Seasonal Hemoprotozoal Disease Incidence for Sedentary and Migratory Herds | 62 |
| 10. | Animal Losses for the Sedentary and Migratory Herds, Jan-Dec 1983 | 64 |
| 11. | Voluntary Intake of Forage by Cattle Grazing on Cracking Clay | 66 |
| 12. | Agronomic Characteristics of the Nuba Sedentary System | 69 |
| 13. | Composition and Productivity of the Livestock Component in the Nuba Sedentary System | 72 |
| 14. | Qualitative Evaluation of Non-Replicated Legume Screening Trials at the Telo Research Site, Kadugli-1983 Season | 82 |
| 15. | Weight Changes in Control and Native-Hay Fed Groups of Cattle During the Late Dry Season (Non-Lactating and Non-Pregnant Females) | 90 |
| 16. | Crude Protein Content of Feeds (%) | 94 |




F 05

Page

17. Gain in Weight during the Rainy Season (Period June 28 to October 8, 1983)..... 97

18. Uses of Ox-drawn Carts and Comparison with Traditional Human Labor in Two Nuba Villages..... 99

19. Pastoral Farming System in Sandy Soils West/Northwest of El Obeid..... 103

20. Production Characteristics of Livestock in a Nomadic Pastoral.. 106

## LIST OF FIGURES


| | | Page |
|---|---|---|
| 1. | Broad Eco-Climatic Zones in Sudan | 2 |
| 2. | Mean Annual Rainfall in Sudan | 3 |
| 3. | FSR&D Activity Time-Frame and Focus for Extensive Livestock Systems | 9 |
| 4. | Growth Stages in Tall Annual Grasses such as *Brachiaria obtusiflora* | 21 |
| 5. | Changes in the Composition of Desirable Herbaceous Species in Exclosures | 26 |
| 6. | Changes in the Composition of Undesirable Herbaceous Species in Exclosures | 26 |
| 7. | Changes in the Composition of Herbaceous Species in Unfenced Range Sites following Fire in December 1982 | 27 |
| 8. | Comparison of Herbaceous Composition in a Grazed Unburnt Site with an Adjacent Ungrazed Burnt Site on a Jebel Hillside | 27 |
| 9. | Herbage Availability and Utilization by Livestock and Losses from Various Causes over the Year | 32 |
| 10. | Transhumant Baggara System | 40 |
| 11. | Changes in Weight of the Migratory and Sedentary Herds (Aug. 1982 to Dec. 1983) | 49 |
| 12. | Seasonal Weight Changes of Mature Cows Compared to Growers (two - three years) | 51 |
| 13a. | Weight Changes of Migratory and Sedentary Herds During the Dry Season 1983 | 52 |
| 13b. | Weight Changes of Migratory and Sedentary Herds During the Rainy Season 1983 | 52 |
| 14. | Seasonal Variations in PCV for Adult and Calf/Yearling Groups | 55 |
| 15. | Seasonal Variations in PCV, for Migratory and Sedentary Herds | 55 |
| 16. | Seasonal Variations in Serum Protein for Adult and Calf/Yearling Groups | 57 |




F 05

Page

17. Seasonal Variation in Serum Protein for Migratory and Sedentary Herds ..... 57

18. Seasonal Variations in Nitrogen Retention and Digestible Protein Intake for Calf/Yearling Groups ..... 58

19. Seasonal Fecal Ova Counts for Calf/Yearling Groups ..... 60

20. Nuba Sedentary System ..... 74

21. Results of Supplemental Hay Feeding to Sedentary Nuba Cattle... 90

22. Change in Weight of Grazing Bullocks Receiving No Supplement, or Supplemented with either GN Hay, Sorghum Straw, or Native Hay ..... 95

23. Growth of Bullocks During Rainy Season ..... 96

24. Pastoral Production System ..... 101

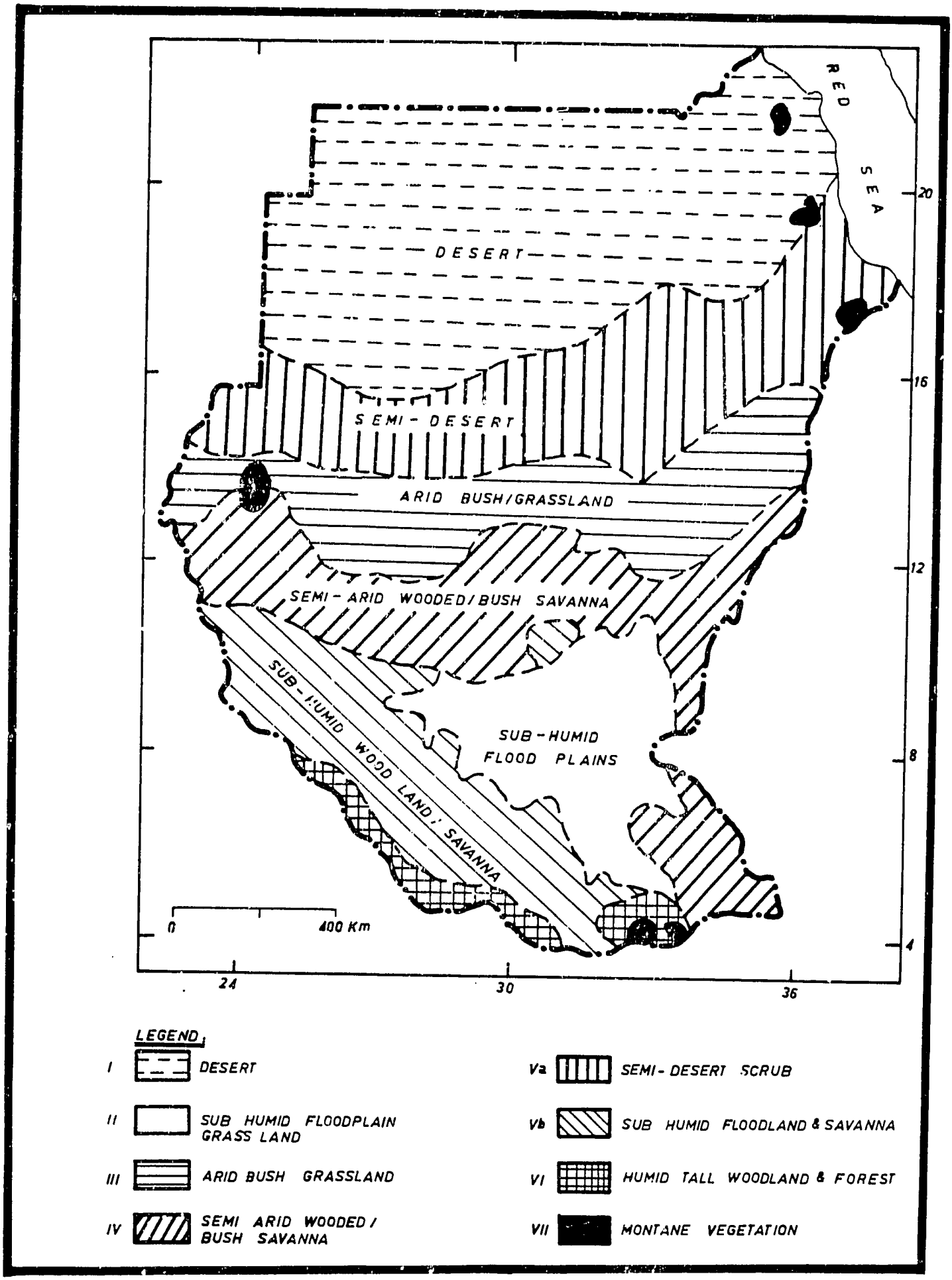
# I. INTRODUCTION

## Sudan

Arid and semi-arid zones cover approximately 50 percent of tropical Africa. Land-use practices in these areas are dominated by traditional forms of pastoralism ranging from sedentary to highly nomadic systems of livestock production. In arid regions, cropping activities are marginal and localized in distribution, as well as opportunistic in nature, with growing seasons of 70-90 days in years of good rainfall. In these regions, complex interactions between livestock and crops occur while migratory patterns of livestock management still predominate.

A general classification of livestock production systems has been attempted for Africa by Winrock International (1981) based on climatic characteristics, the predominant species of livestock and crops produced and on the relative economic importance of livestock, cropping, and mixed-farming systems to the overall agricultural sector. In Africa, three basic livestock systems predominate. Medium rainfall areas are largely characterized by mixed cropping/livestock systems which account for over 46 percent of Africa's ruminant livestock population and approximately 40 percent of the human, agricultural population. This mixed-farming system contains an agronomic component dominated by maize production, and a livestock component with diverse mixtures of ruminant and non-ruminant animals. The remaining two systems occupy low-rainfall areas. Both are livestock-based and are dominated by nomadic pastoralism, one system undertaking the limited cultivation of millet and/or sorghum. Although supporting only 25 percent of Africa's rural population, these combined systems contain nearly 50 percent of the continent's ruminant livestock.

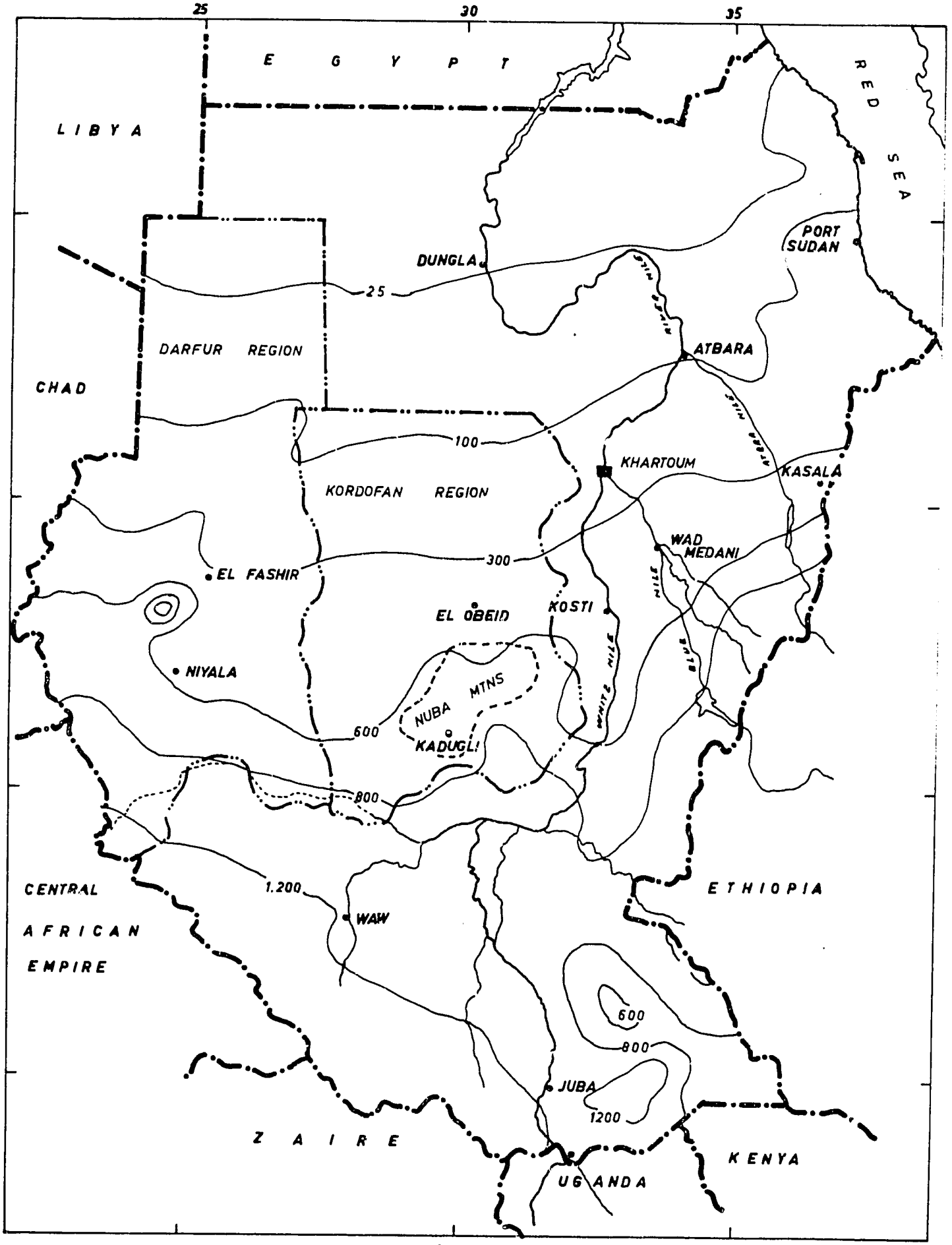
FIGURE 1: BROAD ECO-CLIMATIC ZONES IN SUDAN






F 05

FIGURE 2: D. R. OF SUDAN, MEAN ANNUAL RAINFALL MAP






F 05

Scale 1:10,000,000

Table 1: Characteristics of Eco-Climatic Zones in Sudan

| | Mean Rainfall and (Evapo-transpiration) | Total Area | Portion of Area of Sudan | Estimated Potential Carrying Capacity |
|---|---|---|---|---|
| | - mm - | - $km^2$ - | - % - | ha/TLU |
| I. Desert on skeletal eroded soils, clay pans, gravel pavements, and wind-blown sands | 0 - 100 (>2500) | 722,400 | 28.9 | 30 |
| II. Semi-Desert Scrub on eroded soils, wind-blown sand, compact non-cracking clays | 100 - 300 (2200 - 2800) | 490,200 | 19.6 | 20-30 |
| III. Arid Low Bush-Grassland on stabilized and wind-blown sand, and various cracking and non-cracking clays | 300 - 500 (1800 - 2400) | 294,120 | 11.8 | 6-20 |
| IV. Semi-Arid Bush/Wooded Medium-tall Savanna on compact sandy clays and loams, and cracking and non-cracking clays | 550 - 850 (1600 - 2400) | 392,160 | 15.7 | 3-6 |
| V. Sub-Humid | 850 - 1300 | | | |
| A. Woodland/Wooded Tall-Grass Savanna on cracking clays, iron-stone soils and non-cracking sandy-clays and loams | (1200 - 1600) | 309,600 | 12.4 | 1-3 |
| B. Floodplain Tall-Swamp-Grasslands on dark cracking clays | | 245,100 | 9.8 | 1-3 |
| VI. Humid Tall Woodland Savanna/ Closed-Canopy Forest on in-situ derived sandy clays and loams, and alluvial soils | 1300 (<1400) | 36,120 | 1.5 | 1-5 |
| VII. Montane Closed-Canopy Forests, Woodlands, and Short and Tall Grass Meadows on varied soil types | variable rain-fall and evaporation ecology affected elevation as well as climate | | | variable |
| TOTAL | | 2,496,150 | 100.0 | |



F 05

Sudan is the largest country in Africa with a total land area of approximately 2.5 million $km^2$ and a population of over 20 million. Topographically, the country is a vast plain with only occasional hill and mountain ranges such as the Red Sea Hills in the Northeast, Jebel Mara in the West, the Nuba Mountains in the central portion, and the Imatong Mountains in the South. Sudan encompasses a diverse array of ecological zones which roughly follow a north-south gradient, ranging from desert conditions and sparse scrubland to the north, through arid and semi-arid brushlands and wooded savannas, to lush grasslands, tall woodlands, and closed-canopy forests in the South (Figures 1 & 2; Table 1). It is estimated that the potential livestock utilization of these zones represents 57 percent of the country (1.4 million $kms^2$) with 79 percent of this figure, i.e., 45 percent of the country occupying the drier ecological zones I to IV.

Sudan's national herd currently numbers approximately 53 million head (Booker et al, 1981), with 18 million cattle, 19 million sheep, 13 million goats, and 3 million camels. In terms of Tropical Livestock Units, these numbers collectively represent 30.4 million, accounting for 17.7 of Africa's ruminant population (Winrock, 1981). Cumulative percentages show (Booker, et al, 1981) that the North of Sudan holds approximately 75 percent of all livestock and 65 percent of the cattle, with South Darfur region being the most important cattle producing area.

Cattle generally fall into several major classes; Baggara cattle of Southern Kordofan and Darfur; Butanna and Kenana of Northern Kordofan; and Nilotic cattle of the South. Estimates of respective herd size place Baggara/Butanna/Kenana herds at approximately 11.3 million, on a National basis, and Nilotic cattle at approximately 6.6 million (LMMC, 1980). Sheep are basically of two types (Booker et al, 1981), the desert sheep of the North, approximately 14 million head and Nilotic sheep of the Eastern and Central Regions, approximately 5 million head. Goats are found throughout the Sudan, the Nubian being the most numerous, especially along the Nile rivers and in densely populated areas of Northern Sudan. Camels are concentrated north of latitude 12°N, although they

move South to approximately 10°N during the dry season. Northern Kordofan is resident to approximately 36 percent of the total national camel herd (Booker et al, 1981).

Economically, agriculture contributes approximately 40 percent of the total Gross Domestic Product and approximately 95 percent of total export earnings, while providing a livelihood for 80 percent of the population (Booker et al, 1981). Livestock account for approximately one-half of agriculture's contribution to the GNP, while contributing a much smaller percentage to total export earnings. Total foreign exchange earnings derived from livestock exports amounted to the equivalent of $39 million in 1979/80, rising to over $70 million in 1981/82. Export earnings in 1982/83 were about at parity with 1981/82 figures (LMMC, 1983), although cattle exports during this period were only about 50 percent of the 1981/82 level, as a result of quarantine measures imposed by importing countries in response to Rinderpest outbreaks in Sudan's cattle producing areas. In spite of this fact, sheep exports rose by almost 23 pecent, offsetting potential foreign exchange losses resulting from decreased cattle exports (LMMC, 1983). During the period from 1979 through mid-1983, sheep exports accounted for over 90 percent of the total foreign exchange earnings attributable to livestock (LMMC, 1983; camel exports to Egypt are not included in this figure, since they are administered by the Ministry of Commerce).

In Western Sudan the four provinces of North and South Darfur and North and South Kordofan represent an area of approximately 850,000 $kms^2$ (35 percent of Sudan) and contain a population of approximately 5 million. In terms of national agricultural production, the livestock component of these provinces contribute an estimated 45 percent of the cattle, 37 percent of the sheep, 32 percent of the goats, and 65 percent of the camels. The agronomic sector contributes 90 percent of the millet, 52 percent of the sesame, 46 percent of the groundnuts, 17 percent of the sorghum, 6 percent of the cotton, and 90 percent of the tree product, gum arabic.

In response to the rising demands of an increasing population and in recognition of the agricultural importance of traditional, rain-fed production systems to the National economy, the Agricultural Research Corporation has undertaken to

implement a farming systems research and development program in Western Sudan. The organization charged with implementing this program is the Western Sudan Agricultural Research Project.[1]

## Research Strategy

Fundamental to successful, long-term improvements in traditional systems of extensive livestock production, is the adoption and implementation of a research/development strategy which addresses the needs and priorities of the producer, while recognizing the interdependencies between these and the physical and biological environment. The conceptual framework should be comprehensive in nature in order to develop an adequate understanding of the production system and the primary constraints which adversely impact on sustained, long-term productivity. The objective is to develop technologies which address the causes of production constraints and reduce their detrimental impacts.

The following sections of this report summarize the activities of the Range/Livestock Section for 1982/83. Diagnostic and investigative activities, in addition to in-herd and on-range trials are discussed. The focus of research activities has been on identifying the dynamic interrelationships between traditional livestock production systems, i.e., sedentary, transhumant, and nomadic, and their management of the natural resource base; and further, to design appropriate interventions to allow producers to more efficiently utilize their physical and biological resource base to improve their production enterprises. Efforts directed at improving the management and utilization of natural resources are considered essential to achieve long-term stability in the productivity of both livestock and range resources.

Farming Systems Research and Development (FSR&D) programs attempt to improve crop and livestock production by focusing on the traditional producer and gaining a better understanding of his production system. The primary objective of FSR&D is the design and implementation of technologies for alleviating the

---

1 The Western Sudan Agricultural Project is sponsored jointly by the Government of Sudan, the United States Agency for International Development, and the World Bank.

production constraints of traditional producers, for improving policies and support services for traditional production, and for improving the livelihood of traditional households (adapted from Shaner et al, 1982). The functional stages of a FSR&D program for extensive livestock production systems, together with their relative time-frame, focus, and objectives, is illustrated in Figure 3.

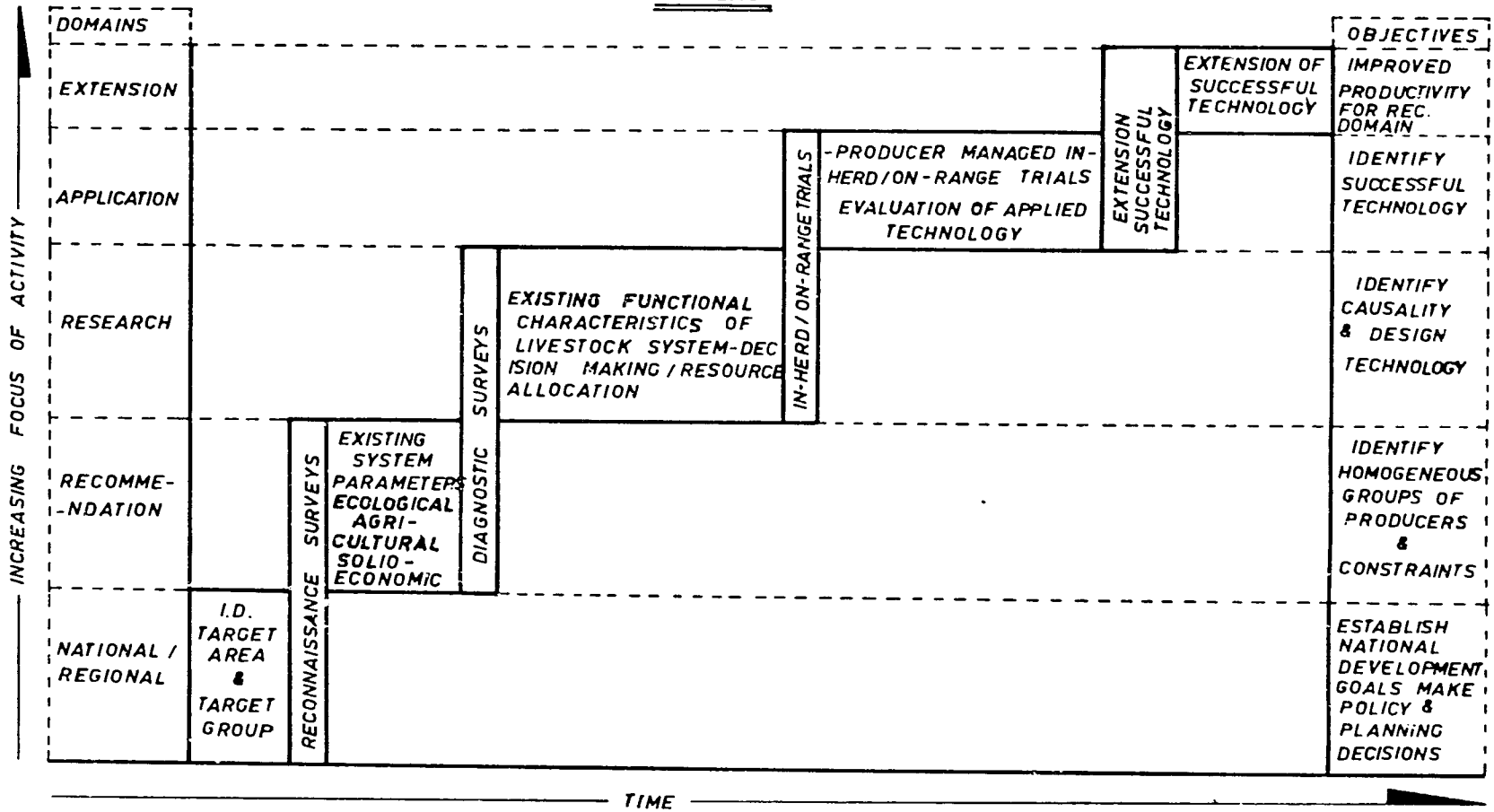
FSR&D activities begin with national policy-makers and planners to identify target areas and target groups. Then FSR&D scientists begin to conduct rapid reconnaissance surveys to zone production systems within the target area according to eco-climatic, agricultural, socio-economic factors in order to identify recommendation domains, i.e., homogeneous groups of producers. Within recommendation domains, diagnostic studies of specific production systems are initiated which focus on characteristics of production enterprises and decision-making/resource allocation within producer households. The objective of diagnostic studies is to clearly identify the functional aspects and causalities of major production constraints and to develop in-herd/on-farm trials aimed at evaluating one or more appropriate technological interventions which address these important production constraints. The final stage in FSR&D is the extension of successful technological interventions throughout a recommendation domain. During this process, FSR&D scientists work closely with policy-makers and planners to coordinate regional and national development priorities with on-going FSR&D activities.

## II. CHARACTERISTICS OF THE PHYSICAL ENVIRONMENT IN SOUTH KORDOFAN

### Climate

The Province of South Kordofan lies within the savanna zone of the Sahelian belt, and can be classified as having a hot, semi-arid climate. Rainfall is dependent on the Inter-tropical Convergence Zone where warm moist air from the equator meets the dry air from permanent high pressure areas over the Sahara. The amount and distribution of rainfall at a particular locality or latitude depends on how far north and for how long the convergence zone penetrates.

FIGURE 3: FSR&D ACTIVITY TIME-FRAME & FOCUS FOR EXTENSIVE LIVESTOCK SYSTEMS






F 05

Rainfall varies from about 550mm in the north to over 800mm in the south. The rains occur in a single season (khareef) primarily from June to September, although some rain also falls in May and October, particularly in regions farther south where the season is more extended. Unseasonal rainfall is rare. A short hot season (deret) from October to November occurs immediately after the rains, followed by a cool dry season (shitta) from December to February, and the main hot season (seif) from March to early June.

Temperatures are associated with the annual migration of the zone of maximum insulation, but modified by rainfall. The hottest months in Kadugli are March and April, with daily means of 30-32°C, and monthly maximums of 39-41°C and minimums of 22-24°C. The coolest months are December and January, with daily means of 25-27°C, and monthly maximums of 34-35°C and minimums of 17-18°C.

Relative humidity and evaporation rates vary with rainfall and temperature. In Kadugli, humidity reaches a low of 15-20 percent in the dry season, and evaporation a high of 230mm/month. During the wet season, humidity rises to 80-90 percent, and evaporation drops to about 150mm/month.

Rainfall and evaporation rates have been used as a basis for classifying rangelands and potential forms of land-use in East Africa (Pratt, et al, 1966) because of the great influence these factors have on soil moisture, and the resulting effect on plants and animals, as well as the activities of man. Of these factors, rainfall has been described as the most important in terms of an area's ecological and agricultural potential (Brown, 1963; Woodhead, 1970).

## Geology

The province is characterized by flat or gently undulating plains of cracking and non-cracking soils, interspersed with hills or jebels of basement complex rock and their associated footslopes. Topographically, elevation varies from about 500m in the plains to over 800m at the tops of hill ranges, with a maximum range of 400m to 1,200m.

In the Nuba Mountain system of South Kordofan, the jebels consist mainly of granites, mica schists, and quartzites. These jebels and their footslopes account for approximately 40 percent of the land surface in the region studied by Hunting Technical Services (1981), with the plains occupying the remaining 60 percent.

Erosion is the primary geomorphic process in the area, particularly from water run-off. The extent of erosion depends on the soils, topography, and plant cover, and shows potential for further increase due to poor land-use practices (FAO, 1981)

## Drainage Patterns

Drainage is generally seasonal in nature and originates in the jebels with a gradual merging into the surrounding plains. Some of the lower lying areas become inundated during the rainy season, but such regions are usually small and localized in distribution. Major drainage units in the southern portion of the province include the Khor el Berdab and Khor el Afin, which were former tributaries of the Bahr el Arab system. Both drain southward, terminating in road depressions of alluvial clays, namely Lake Keilak and Lake Abyad. These lakes are the only perennial sources of natural surface water, although their water levels vary considerably throughout the year. Farther north, the pattern of drainage is north-east toward the Khor Abu Habl, which flows eastward to the Nile, but with considerable stagnation before reaching its delta east of Umm Ruwaba. Principal tributaries draining into the Khor Abu Habl, are the Wadi Abu Seiba, Khor Sungalla, Khor Umm Berembeita, and Wad Shallango. Important drainages to the west of the Nuba Mountain region include the Wadi el Ghallah and the Wadi el Azraq.

## Water Resources

Apart from the perennial lakes of Keilak and Abyad, sources of water include hafirs (excavations in clay for collecting surface run-off), wateryards (consisting of one or more boreholes with steel storage tanks and watering troughs), hand pumps, various types of traditional hand-dug wells ranging in depth from

0.5m to 12m, and ephemeral ponds of varying duration and size. The hafirs, which total about 90 in the province, were constructed in the 1950's, but due to siltation and lack of maintenance, their useful storage capacity totaling some 2 million cubic meters has been reduced by over 35 percent. A hafir rehabilitation program is now well underway by UNICEF and the National Administration for Water.

Wateryards are less numerous, but provide a valuable source of water for both people and animals, particularly in some of the larger settled areas such as Kadugli, Dilling, Lagawa, and Hamra. Hand pumps, specifically designed for human needs are being developed in the rural areas by the UNICEF and NAW project.

Traditional wells dug by hand to varying depths on the jebel footslopes and in the beds or banks of seasonal streams, form the major supply of water for human and animal needs, particularly during the dry season after ephemeral supplies become depleted. These wells are clearly limited to areas with relatively high water tables, which are rare in the plains. Thus, apart from a few functional hafirs and occasional streams, the extensive cracking and non-cracking clay plains are virtually devoid of perennial water supplies due to the nature of the soils and underlying geology.

Thus, the availabilty and distribution of water serve as an important constraint to crop and livestock production because these activities are physically limited to areas within reach of adequate water supplies. This is not to say that existing water services be improved or expanded upon without studies on the environmental and socio-economic implications; rather it suggests that under proper management, there is considerable scope for improvement.

## Soils

The types and distribution of soils in South Kordofan are complex. For the Nuba Mountain region, Hunting Technical Services (1981) identified six broad soil types based to a large extent on topography and land-form. However, there is a high degree of variability within these soil-topographic zones. A summarized description of major soils in the Nuba Mountains is presented below, based on

Hunting's general classification, but with notes on important variations. This is followed by brief outlines on the soils to the north and south of the Nuba Mountain system.

Nuba Mountain Soils

(1) Jebel Soils: Most of the slopes and tops of jebels consist of bare rock and shallow, skeletal sands and sandy loams. A small portion is characterized by somewhat deeper profiles of brown, coarse-textured colluvial sands and sandy loams and clays. The latter soils typically occupy wetter sites on fairly flat surfaces, such as on the tops of jebels, or in sumps between peaks and ridges. Jebel soils dry out rapidly and tend to be infertile, with low organic matter content. They are also susceptible to erosion, because of their steep slopes and the frequent removal of plant cover by dry season fires. Nevertheless, the nature of the soils permits ready penetration of both water and plant roots, which often tap water from depressions on the underlying surfaces of bed-rock.

Although generally unsuited to cultivation, jebel colluvial soils are cropped regularly in some areas, especially where human densities are relatively high. Terracing with rock borders is widely used on small plots to improve soil moisture and effective manuring by containing water run-off. Jebel ranges are also grazed extensively by sedentary livestock, particularly during the wet and early dry season. Overall, jebel soils have low cultivation potential, due to their steep slopes, irregular structure and distribution, high erodibility, and low fertility.

(2) Footslope Soils: Jebel footslopes are composed of reddish-brown soils derived from weathering processes in the hills. They vary from light sands to coarse-textured sandy loams and sandy clays, usually overlying a layer of gravelly loam close to the surface. Rocks and stones are frequently scattered throughout the profile. A major varient is a stony, sandy clay on strongly dissected slopes or undulating plateaus. This could reflect the result of severe erosion, where the topsoil of sandy loam has been removed.

Footslope soils are generally low in organic matter, poorly structured, and erodible, due to their slope, poor water infiltration, and heavy land-use pressures. In distribution, these soils typically form a continuous ring (ranging in width from a few meters to several kilometers) around jebels. It is here where a large portion of the human population is settled, and where most of the garden and near-farms are located. Increasing demands on these soils are resulting in a deterioration of their productivity and potential due to pressures of cultivation, year-round and heavy dry-season grazing by livestock, widespread burning, and excessive tree cutting for construction and fuel.

(3) Plains Residual Soils: These soils are found in the plains and are red and red-brown, medium to fine textured non-cracking clays and clay loams, supposedly derived from prolonged in-situ weathering of basement complex rock and ironstone. They are moderately deep with varying amounts of ironstone nodules through the profile, and a hard, compact surface of low water infiltration and subject to sheet erosion and run-off.

The principal use of these soils is for grazing, particularly early in the rains, and shortly after they end. Cultivation is rarely practiced, despite favorable features of flatness and moderate fertility, because the hardness of these soils results in poor water infiltration, and makes them difficult to cultivate.

(4) Shallow and/or Gravelly Cracking Clays: These soils range from brown surface cracking clays to darker, deeper cracking clays, and most contain variable proportions of gravel and stones on the surface and in the profile. They tend to be fairly shallow and occupy the more dissected and undulating parts of the plains where lateral run-off is considerable. As a result, they are more susceptible to erosion and dry out rapidly after the rainy season. Some of these soils, particularly the brown forms with fine surface cracks, appear to be transitional between the red non-cracking clays and the dark cracking clays described below.

Cultivation is not extensive on these soils because of their irregular distribution, hardness, stony profiles, and poor water retention capacity. Grazing by livestock currently represents the primary use of these soil types.

(5) Dark Cracking Clays: Soils of this type contain an average of 60 percent clay, dominated by montmorillonite, which causes expansion when wet and contraction when dry. The nature of this process, coupled with the presence of deep cracks, give the soil an ability toward self-mulching.

Dark cracking clays occupy a large portion of the plains (over 50 percent in the Central Districts of South Kordofan, HTS 1981), mainly on the middle and lower slopes, and in valley bottoms between hills. Two major sub-types are distinguished. The most common is dark brown in color and 2m in depth, with cracks extending down to 1.5m. The other is grey-black with higher clay contents, and occurs in low-lying areas subject to seasonal or periodic inundation. The former is well suited to cultivation, while the latter is marginal, due to problems with water-logging. Deep land-preparation on these soils is difficult, because they are either too dry and hard, or too wet and plastic. Erosion may also be a problem in the more undulating parts of the plains, especially after the cracks have soaked up. In such instances, excess water accumulation on the surface during heavy rainstorms may result in substantial lateral run-off, and loss of top-soil.

Other important factors affecting crop production on the cracking clays are low levels of nitrogen and available phosphorus. Low nitrogen content appears characteristic of the soils, but is also related to poor cultivation practices which lack the use of fertilizers or adequate crop rotations involving food or forage legumes. All of the cracking clays provide a valuable source of grazing to both sedentary and migratory livestock during the dry season.

(6) Alluvial Complex Soils: These soils are highly variable, due to the topographical gradient between the steep jebel hillsides and the flat low-lying plains. In the upper catchments, the soils range from coarse

sandy loams to fine clays. Toward the plains, flooding is generally restricted to narrow belts, primarily composed of cracking clays. These are best developed in areas where drainages terminate in broad depressions subject to seasonal flooding.

The principal use of alluvial soils is for dry season grazing. Cultivation is largely confined to scattered pockets of irrigated horticultural crops adjacent to the banks of seasonal streams. Some grain is also grown where flooding is light, or absent. More extensive cultivation, as well as earlier grazing, is limited by periodic inundation during the rains.

Soils in the Northern Regions of South Kordofan

(1) Stabilized Sands or Qoz Soils: Qoz soils form extensive sheets and dunes from the basement complex zone eastward to the White Nile, and between the northern deserts, the Nuba Mountains, and the Baggara and Regeba repeating soil patterns. A sizeable region in the northern parts of South Kordofan is represented by Qoz soils which are part of a deep aeolian mantle with quartz sand derived from the surrounding Basement Complex, Nubian Sandstone, and Umm Ruwaba sediments.

Qoz sands are typically deep and coarse in texture, acid in reaction, and of low fertility and organic matter content. They are also characterized by high rates of rainfall infiltration, free drainage, low moisture holding capacity, and susceptibility to erosion. Despite these limitations, qoz soils are widely cropped, due to their ease in land-preparation, planting, and weeding. They also provide important seasonal and year-round grazing for livestock where water is available.

(2) Non-Cracking Clays or Garduds: Non-cracking pediplain soils are derived from Basement Complex rock, and consist of flat to gently undulating plains of red clays and brown sandy clays. In distribution, they tend to alternate with the qoz areas, but also form extensive plains in the northwestern regions of the province. These soils contain clay in varying proportions and at different depths in the profile, even though the surface may be sandy. The clay has been affected by sodium of marine or lacustrine

origin (Skerman, 1966). Sodium interacts with the colloidal system of the clay, which then leaches down through the profile. Clays of this kind pass easily into colloidal solution, which fills up the pore spaces of the soil, causing poor aeration and low infiltration. The result is an impermeable clay, with high water losses from run-off and evaporation. Surface crusts typically form on these soils, which further reduces rainfall penetration, and interferes with seed germination. The process is accentuated by the removal of plant cover from heavy grazing pressures and fires, leaving an exposed surface layer of truncated clay pans common to gardud soils.

Non-cracking clays are relatively fertile, but are rarely cultivated, due to difficulties in tillage and poor water infiltration. Grazing is currently the major use of these soils, primarily in the wet season when run-off collects in small depressions which subsequently provide important ephemeral sources of water for both people and animals.

## Soils South of the Nuba Mountains

Soils in this region basically fall into two major categories, dark cracking clays and red gardud soils, the latter exhibiting a rather patchy distribution. Detailed information on these soils is not extensive, but many of their characteristics are similar to those described earlier. For the cracking clays, the major distinction is their more extensive nature, better infiltration, and lower erosion potential. The two latter features are related in part to flatter topography and a more uniform and persistent cover of herbaceous vegetation. Areas adjacent to the river networks of the Bahr el Arab, Bahr el Ghazal, and White Nile are seasonally flooded and appear to be fairly fertile. However, cultivation is precluded in such areas by prolonged water-logging. Cracking clays not subjected to seasonal inundation are not cultivated extensively due to the lack of human water, and the high incidence of disease and insect pests during the growing season. Similar problems affect livestock, and consequently, grazing is confined to areas and/or periods in the dry season, with available water.

Gardud soils are similar in structure to those in the Nuba Mountains, but tend to have higher infiltration rates due to the better surface characteristics and less patchy ground cover. Uses of these soils are not significantly different from other non-cracking clays, because of similar limitations.

## III. RANGELAND RESOURCES IN SOUTH KORDOFAN

A sound understanding and evaluation of the primary resource base is fundamental to any comprehensive program for integrating improvements in livestock production with the long-term maintenance and stability of the environment. Research into an area's natural resource base should be addressed in the context of existing land-use practices, and how these impact on forage conditions and the potential of rangelands to support livestock production, as well as other forms of land-use.

Baseline information on the current composition, productivity, and ecological status of rangelands in South Kordofan is summarized below. Emphasis is placed on the Nuba Mountain region where most of the research to date has been conducted. This is accompanied by investigations into the factors responsible for limiting or maintaining forage conditions at sub-optimal levels, followed by a discussion of the resulting implications for improvements in management and patterns of resource utilization.

### Collection and Identification of Plants

Investigations of rangelands necessitates a proficient appreciation of the flora and the environmental conditions under which each species is found. Extensive plant collections provide a first step in achieving this objective, and a herbarium for the province is being established as a reference library for scientists and agriculturalists working in the region. Approximately 250-300 species of plants have been identified, and a separate report on these is being published, complete with annotated notes on vernacular names, physiognomy, abundance and distribution, habitat characteristics, and uses.

## Rangeland Classification and Mapping

Rangeland communities in South Kordofan are being classified and mapped according to botanical composition and structure, topo-edaphic characteristics, and climatic factors. Delineation of major vegetation types is being accomplished through the use of land-sat imagery in color composites at a scale of 1:250,00, and aerial photographs at a scale of 1:50,000. Quantitative descriptions of the structural and compositional parameters of herbaceous and woody components in the vegetation incorporate the use of a transect sampling procedure in randomly selected sites within each range community.

The basic characteristics of major rangeland communities described to date are presented in Bunderson (Ann. Rep. 1981) according land-form and soils, and a detailed classification is in preparation. As in other parts of tropical Africa, vegetation is typically heterogeneous and complex, reflecting a wide range of environmental conditions. In the Nuba Mountains, a general distinction is made between the vegetation of the jebels, their footslopes, the surrounding clay plains, and riparian situations associated with seasonal drainage lines and flooding. Within each of these zones are found several plant communities, all of which exhibit some degree of variability, due to local changes in soils or relief, and to disturbing influences of man and his livestock.

Although the classification of rangelands outside the Nuba mountain region has not been extensive, some preliminary surveys have been conducted in considerable detail on a localized basis. Data regarding results of these surveys for qoz and gardud soil types in areas to the south and southwest of Dubeibat, and on cracking clays and red non-cracking soils south of Lake Keilak and southwest of Talodi will be presented on completion of additional surveys.

## Rangeland Evaluation

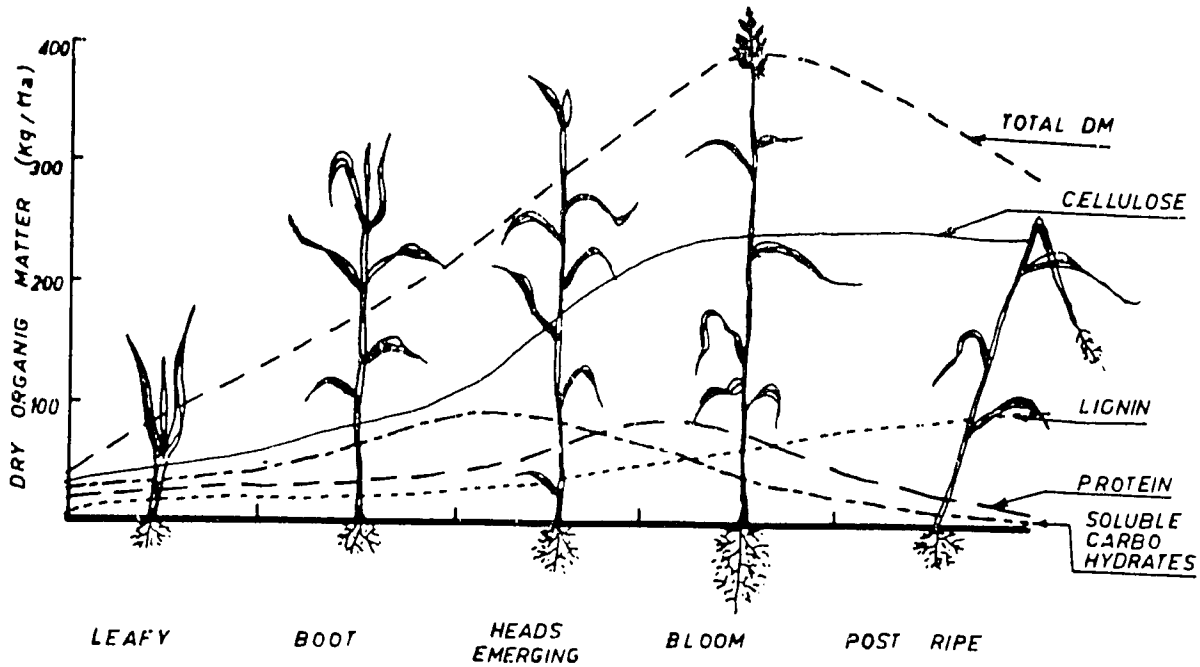
Descriptions of the structure and composition of rangelands in the Nuba Mountain region are being accompanied by assessments of range condition and productivity, as influenced by factors such as the seasonality and intensity of grazing, the incidence of fire, cultivation, and the cutting of trees for various purposes.

Evaluations of this kind are essential to an accurate identification of key constraints to the quality and productivity of rangelands, and their carrying capacities for livestock. Assessments are being conducted with the assistance of permanent exclosures and transect lines where changes in plant composition and productivity are monitored over time in relation to the nature and pattern of grazing, fire, and other disturbing factors. Chemical analyses of forages are being carried out in each major range community at different seasons and stages of growth. The results of these analyses will be available later in the year. In addition to data gathered in classifying major range communities, assessments of woody and herbaceous compositon involved permanent exclosures and transect lines in different plant-soil associations, with the latter running through unfenced grazing lands. Herbage production was measured at the peak of the growing season in ten exclosures, each representing different communities. (For details on methodology, refer to proposal 8, WSARP Publication 18.) The primary purpose of the exclosures and transect lines is to monitor and compare differences and changes in vegetation over time in relation to the presence or absence of fire, grazing and tree cutting. A summary of the condition and productivity of rangelands, and the factors affecting these, is presented below.

## Herbaceous Vegetation

With the exception of a few localized plant communities, notably the seasonally inundated grasslands, most rangelands in the Nuba Mountains are in only fair condition, or more specifically, at various stages within this general category, some being in poorer condition than others. This is basically attributed to the dominance in the herb layer by tall, coarse, fast-maturing annuals. Although relatively productive in terms of plant biomass, the nutritional value of these species is low and drops dramatically at maturity, which usually occurs before the end of the rains (Figure 4). By this time, the majority of plants have completed their life-cycle, remaining either in the form of standing straw, or as fallen litter in various stages of decomposition. In view of a recent paper by Breman and de Witt (1983), a brief discussion of differences in forage quality between plants is considered appropriate.

FIGURE 4 GROWTH STAGES IN TALL ANNUAL GRASSES SUCH AS BRACHIARIA OBTUSIFLORA




The pattern of pasture use by both domestic and wild ungulates in Africa has developed in response to the characteristic distributions of physical structure, mechanical properties, and chemical composition within the herb layer. These are largely determined by the growth form of grasses which constitute by far the largest component of the herbaceous vegetation. Since the concentration of cytoplasmic constituents (protein and soluble carbohydrates) is highest in leaves, while that of structural components (primarily cellulose) is highest in stems, forage quality and digestibility are closely related to the proportion of leaves to stems. Thus, because the ratio of fiber to protein increases in all tissues as their size increases, the protein/fiber ratio is highest in young plants, and in those species that never attain great size (French, 1957). As grasses grow, components with high proportions of protein become rarer, and are progressively interspersed by taller, tougher structures. This process is most highly developed in grasses with tall, dense growth-forms such as those commonly

found in South Kordofan. With regard to the aforementioned paper, the authors indicated that forage quality (in terms of crude protein content and phosphorus) is strictly a function of rainfall, and that the relationship is inversely proportional. While it has been long recognized that the protein and mineral content of plants are generally higher in arid and semi-arid regions than in more humid zones, the paper, as presented, makes no mention of the differences in the species and structural growth-forms of plants between these areas. Such differences are basically the determinants of forage quality and not rainfall per se, although the amount and distribution of rainfall clearly influence the types and species of plants found in certain ecological zones as well as the degree of leaching in the soils. It should also be pointed out that higher phosphorus levels in drier regions are partly related to the lower, patchy, and often sparse cover of vegetation, resulting in lower phosphorus uptake. It is more in this context that the inverse relationship between rainfall and forage quality holds.

WSARP scientists at Kadugli consider that the species and growth form of plants is the overriding factor influencing the differential forage quality between the north and south. The implication here is that the structural characteristics of the herb layer in South Kordofan reflect a high stem: leaf ratio, and hence lower quality forage relative to the shorter, leafier, and less stemmy plants in the drier north. This situation is aggravated by the absence of adequate grazing pressures on southern ranges during the growing season. Such pressures tend to promote the growth and establishment of shorter, leafier plants over the taller species, due to the greater ability of the former to withstand heavier grazing. Fires further exacerbate the problem by favoring tall, stemmy grasses in place of more palatable and less fire-resistant species (Bunderson, 1984a). Perennial plants in such cases, suffer reduced vigor and high mortality following the effects of early dry season fires. This results from re-growth out-of-season, which draws on stored food reserves in the roots, coupled with the selective grazing that is attracted by the flush of green grass produced.

Support for these arguments is provided by data presented in Tables 2 to 5 and Figures 5 to 8 (details in Appendix 1, Tables 1 to 15). Changes in herbaceous composition demonstrate a net improvement for exclosure sites where fire and grazing were effectively excluded for the years 1981-1983. Exceptions were

sites 5 and 6, which showed no significant change in desirable species, due to the very low diversity of plants in the area. This greatly reduces the opportunity for rapid changes involving species not currently represented in the vegetation. By contrast, fires deliberately set in exlosure 1, 2, and 3 during the early dry season of 1982, caused reductions in desirable species by as much as 30 percent. Similar effects of fire were observed in permanent transect lines through unprotected areas (see Table 3 and Figure 7). However, under certain conditions, fires were observed to produce positive results. For example, Table 4 shows on cracking clays under high densities of bush, that early dry-season fires reduced the abundance of unpalatable species in favor of more desirable species (See details in Appendix 1, Tables 14 and 15).

Comparisons of areas with different histories of fire incidence and different patterns of grazing (Table 5, Figure 8) provide further support that frequent fires result in vegetation dominated by coarse annuals of low nutritional value. The data presented also demonstrates that moderate grazing, in the absence of fire, leads to considerable improvements in the diversity and structure of the herb layer, and hence improved forage quality and palatability. Such differences were observed in burned, ungrazed sites versus unburned, grazed sites in a jebel range north of Kadugli. The latter was characterized by a relatively short, leafy sward with a 43 percent higher proportion of desirable species, while the former, prior to burning, consisted of a tall, stemmy cover of vegetation dominated by a single species (see Appendix 1, Table 13). Information to be gathered in the growing season of 1984 should help verify the general pattern of events reported here.

## Herbage Productivity

Herbage production was measured from clipped plots at the height of the growing season for each year in all ten exclosures. The results are shown in Table 2. Attempts to evaluate changes in production as influenced by the presence or absence of fire, produced no definite conclusions. This is attributed to a number of factors, as follows:

Table 2: Changes in Herbaceous Cover, Composition, and Productivity under Protection from Fire and/or Grazing

| Field Conditions and Soil Types | Plant Cover 81 % | Plant Cover 83 % | Litter 81 % | Litter 83 % | Bare Soil 81 % | Bare Soil 83 % | Net Change in Desireable Species % | Herb Prod. g/m² 81 | Herb Prod. g/m² 82 | Herb Prod. g/m² 83 | Fire History 78 | 79 | 80 | 81 | 82 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Exclosures | | | | | | | | | | | | | | | |
| 1. Gravelly Grey Sandy Clays | 70.0 | 67.5 | 1.3 | 0.0 | 28.7 | 32.5 | -24.4 | 232 | 213 | 174 | X | X | | | X |
| 2. Red/White Loamy Sands | 76.2 | 70.6 | 0.0 | 0.0 | 23.8 | 29.3 | -21.3 | 198 | 303 | 318 | | | X | | X |
| 3. Dark Heavy Cracking Clays | 93.1 | 81.3 | 2.5 | 0.0 | 4.4 | 18.8 | 029.9 | 691 | 605 | 493 | X | | | | X |
| 4. Red Non-Cracking Clays | 66.2 | 70.0 | 5.0 | 3.1 | 28.8 | 26.8 | +10.4 | 146 | 284 | 487 | | X | | | |
| 5. *Dark Medium Cracking Clays | 70.6 | 68.8 | 17.5 | 18.1 | 11.9 | 13.1 | NS | 181 | 251 | 179 | X | X | | | |
| 6. *Brown Light Cracking Clays | 62.5 | 60.0 | 16.3 | 8.1 | 21.2 | 31.9 | NS | 200 | 202 | 176 | X | X | | | |
| 7. Dark Heavy Cracking Clays | 89.4 | 91.3 | 3.7 | 3.1 | 6.9 | 5.6 | +1.3 per +14.5 | 405 | 438 | 276 | | | X | | |
| 8. Brown Coarse Sandy Clay-Loams | 71.9 | 86.9 | 0.6 | 0.6 | 27.5 | 12.5 | +4.9 | 157 | 343 | 282 | | X | | | |
| 9. Red Sandy Clays and Loams | 80.0 | 91.3 | 0.0 | 6.3 | 20.0 | 2.5 | +13.9 per +2.8 | 316 | 484 | 394 | X | | X | | |
| 10. V. Dark Heavy Cracking clays | 100.0 | 97.5 | 0.0 | 0.6 | 0.0 | 1.9 | +6.3 | 1123 | 1334 | 912 | X | X | X | | |

* Herbaceous species of extremely low diversity inside and surrounding these exclosures. The low diversity of plants greatly reduces the chances for significant changes in composition, other than between the exisitng species.

Table 3: Herbaceous Vegetation Changes Monitored from Permanent Transects in Unprotected Sites

| Transect and and Soil Types | Herb Cover 82 % | Herb Cover 83 % | Litter 82 % | Litter 83 % | Bare Soil 82 % | Bare Soil 83 % | Net Change in Desireable Species % | Fire History 78 | 79 | 80 | 81 | 82 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Dark Heavy Cracking Clays (Plain) | 92.0 | 85.0 | 2.0 | 0.0 | 6.0 | 15.0 | -19.6 | X | | | | X |
| 2. Red-Brown Non-Cracking Sandy Clay (Jebel Footslopes) | 78.8 | 72.5 | 1.2 | 0.0 | 20.0 | 27.5 | -16.1 | | X | | X | X |

Table 4: Herbaceous Vegetation Change Under an Early Dry Season Burning Regime

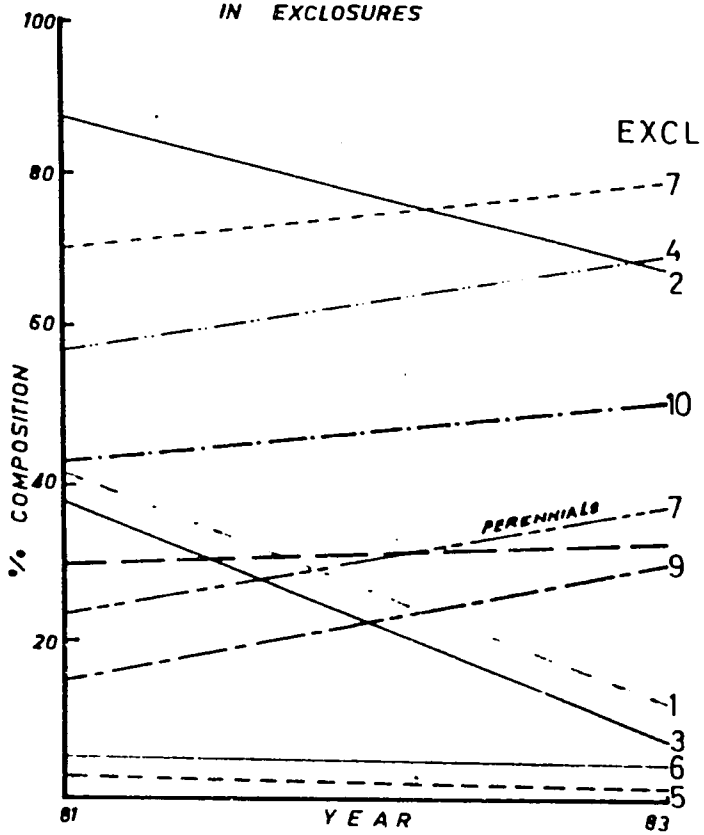
| Transect and and Soil Types | Herb Cover 82 % | Herb Cover 83 % | Litter 82 % | Litter 83 % | Bare Soil 82 % | Bare Soil 83 % | Net Change in Desireable Species % | Fire History 78 | 79 | 80 | 81 | 82 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Dark Heavy Cracking Clays* (Plains) | 85.0 | 87.0 | 1.0 | 0.0 | 14.0 | 13.0 | +29.1 | | X | | | X |
| 2. Dark Heavy Cracking Clays* (Plains) | 88.0 | 91.0 | 1.0 | 0.0 | 11.0 | 9.0 | +11.0 | | X | | | X |

* The two sites here with the early dry season burning regime are part of a study on bush encroachment and its control. Both sites are adjacent to each other on cracking clays where the bush density exceeds 1000/ha for plants over 2 meters in height.

Table 5: Comparison of Herbaceous Composition on a Jebel Hillside: Grazing and No Burning v.s. Burning and No Grazing

| Transect and and Soil Types | Herb Cover % | Litter % | Rock/Soil % | Desireable Species % | Net Difference | Fire History 78 | 79 | 80 | 81 | 82 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Grazed Unburnt Rocky Coarse Soils (hillside) | 70.9 | 0.0 | 29.1 | 56.5 | 43.2 | | | | | |
| 2. Ungrazed Burnt Rocky Coarse Soils (hillside) | 81.8 | 0.0 | 18.2 | 13.3 | | X | X | X | X | X |

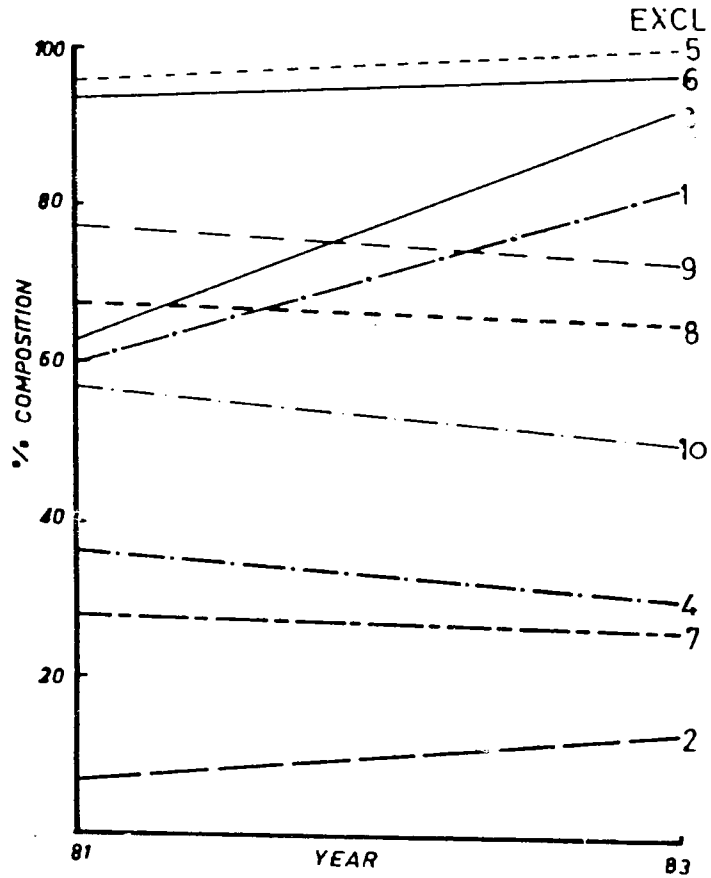
FIGURE 5 CHANGES IN THE COMPOSITION OF DESIRABLE HERBACEOUS SPECIES IN EXCLOSURES




| | | | | | |
|---|---|---|---|---|---|
| | EXCL 1* | | EXCL 5 | | |
| | EXCL 2* | | EXCL 6 | | |
| | EXCL 3* | | EXCL 7 | | EXCL 9 |
| | EXCL 4 | | EXCL 8 | | EXCL 10 |

*BURNED NOV. 82

FIGURE 6 CHANGES IN THE COMPOSITION OF UNDESIRABLE HERBACEOUS SPECIES IN EXCLOSURES




LEGEND:

| | | | | | |
|---|---|---|---|---|---|
| | EXCL 1* | | EXCL 5 | | |
| | EXCL 2* | | EXCL 6 | | |
| | EXCL 3* | | EXCL 7 | | EXCL 9 |
| | EXCL 4 | | EXCL 8 | | EXCL 10 |

*BURNED NOV. 82

FIGURE 7 CHANGES IN THE COMPOSITION OF HERBACEOUS SPECIES IN UNFENCED RANGE SITES FOLLOWING FIRE IN DEC. 1982.

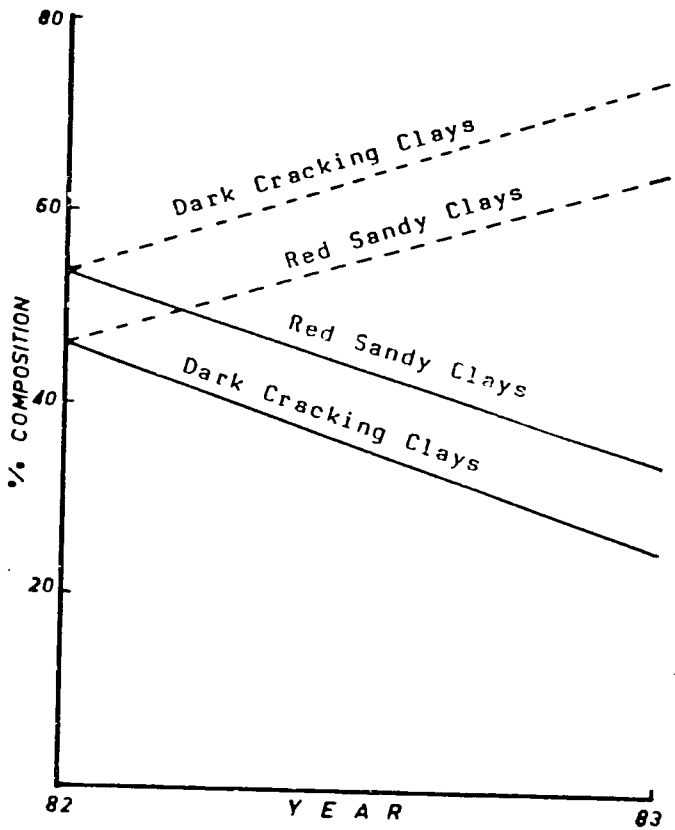
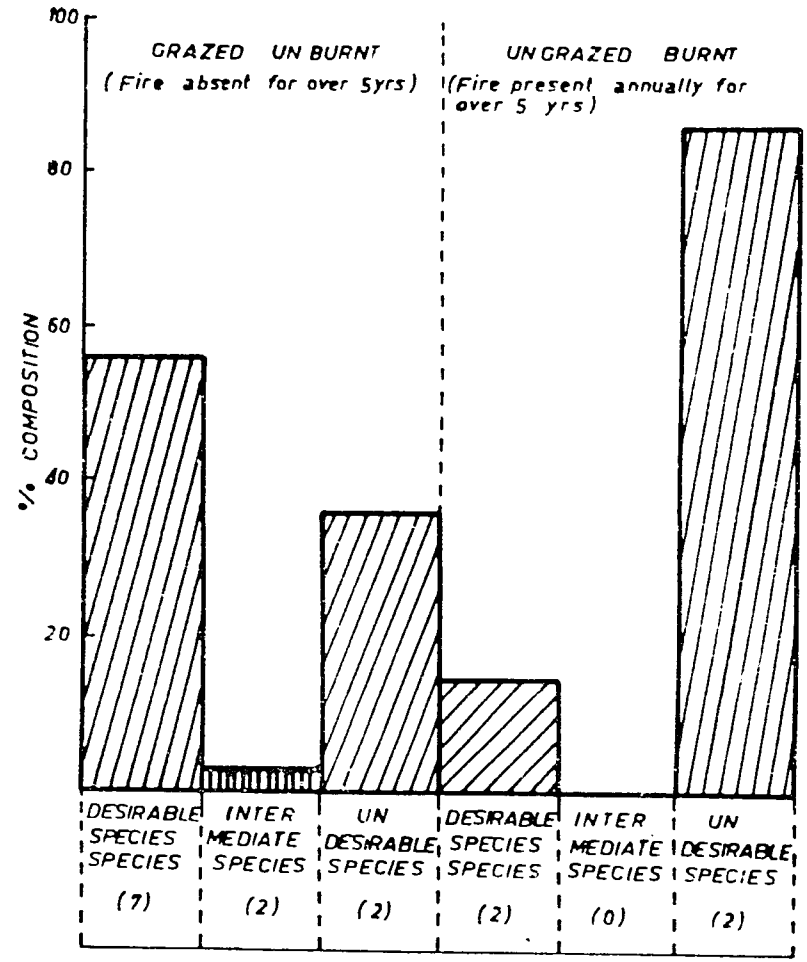



FIGURE 8 COMPARISON OF HERBACEOUS COMPOSITION IN A GRAZED UNBURNT SITE WITH AN ADJACENT UNGRAZED BURNT SITE ON A JEBEL HILLSIDE.
(Rocky sandy loams and clays)



(a) primary production is closely related to the amount and distribution of rainfall at a given location; thus, differences attributable to the effects of fire are obscured by fluctuations in rainfall from year to year,

(b) herbaceous vegetation in most exclosures exhibited considerable variability in ground cover on a micro-scale; due to the random sampling procedure used in measuring production, differences observed between years could be related to variability between the plots sampled within a particular exclosure.

A new technique has now been developed by the Kadugli range scientist to reduce problems of this nature. The technique has been under test since 1981, and with the refinements being made, the results should be applicable to data collected in each of the exclosures over the past three years. These will be published following the collection and analysis of data in 1984.

Woody Vegetation

Quantitative data gathered from extensive surveys for classifying the structure and composition of woody vegetation show considerable variability in the ecological status of different range communities. In the cracking clays, for example, the density of woody plants frequently exceeds 1000/ha, and certain species associated with these soils show rapid regenerative capabilities with high resilience to land-use pressures. In areas with coarse-textured soils, the density of woody plants is generlly lower, and trees such as *Anogeissus leiocarpus*, *Sclerocarya birrea*, *Albizia amara*, *Combretum hartmannianum*, *Prosopis africana*, *Acacia gerrardii*, *Terminalia laxiflora*, and *Balanites aegyptiaca* are steadily disappearing, due to high population demands for wood and wood products. In addition to lower tree densities, the age-class distribution of species in these areas demonstrates that natural replacement is not keeping pace with the increasing pressures on these plants. Part of the problem is that favored trees for fuel and construction commonly occur on soils

where human and small ruminant densities are high. Under pressures from selective browsing, frequent burning, and rising demands for land and wood resources, seedling establishment and growth are extremely difficult. The result is a declining abundance and diversity of woody vegetation.

In terms of monitoring activities, changes in the structure and composition of woody vegetation from exclosures and belt transects through unfenced rangeland, are scheduled for evaluation in June, 1984. Earlier measurements of change are considered unnecessary because of the much slower growth characteristics of woody plants, i.e., little change is expected over short periods of time. However, because early dry-season fires were set inside three of the ten exclosures in 1982, it was important to examine what impact this had on the woody component for all three sites. Appendix 1, Tables 1, 2, and 3, show changes in the densities and heights of woody plants by species for exclosures 1, 2, and 3, following the occurrence of fires in 1982. The results indicate that early dry-season fires have little or no impact on mature trees associated with cracking and non-cracking soils. Furthermore, the net increase of seedlings and younger-age plants in all three sites suggests that for many species, early dry-season fires also have no significant effect on the survival and growth of young plants. These conditions indicate that a higher proportion of seedlings and young plants should be represented in many range communities. The fact that this often does not occur, implies that some other factor is affecting the survival of young plants. Preliminary observations indicate that browsing by small ruminants has a severe impact on young plants of many species in areas where the densities of these animals is high. It is also postulated that late dry-season fires, occurring after woody growth has started, adversely affect seedling establishment and growth in young plants. The combined effects of dry-season fires and selective browsing could explain the low density of young woody plants in many areas, particularly where livestock numbers are high year-round. Verification of the general trends suggested here is expected on completion of monitoring activities with the ten exclosures and over twenty transect belts located in different plant communities. Measurements will be carried out in June and July 1984.

## Factors Influencing Range Condition and Livestock Carrying Capacities

In terms of grazing, the existing biomass of livestock in the Nuba Mountains consumes only 6 percent of the net primary production (Table 6). Resource utilization here is clearly inefficient, compared with other regions in Africa where this percentage frequently exceeds 25 percent, reaching a maximum of 36 percent (Bunderson, 1984b). Utilization levels by livestock greater than 40 percent of the net primary production invariably lead to overgrazing in extensive African systems, if continued on a long-term basis. The low grazing percentage by livestock in the Nuba Mountains is related to factors which greatly influence the abundance and quality of forage available to the animals. Given these limitations, livestock utilize a considerably higher proportion of the primary projection, within the region physically available for grazing, than is indicated by the overall 6 percent average (see Figure 9). The most important factors affecting resource availability and forage quality are briefly discussed below.

### 1. The Nature and Pattern of Fire

Investigation into the extent and pattern of burning in the Nuba Mountains was prompted by important implications for range-livestock production. The analysis of color-composite land-sat imagery spanning a period of eight years, reveals that fires annually burn 30-50 percent of the land surface. An estimated 80-90 percent of these fires occur during the early dry-season, from October to January. Most fires are started by man for a variety of reasons, ranging from negligence on the part of charcoal burners and travellers, to intentional burning by specific groups such as sedentary cultivators to discourage the settlement and grazing of migratory livestock in the vicinity of their villages and cultivated fields.

Herbage losses that accrue from burning in the Nuba Mountains account for 25-30 percent of the net production on an annual basis. This was determined from the change in herbage biomass over the year, weighted across vegetation types, taking into account estimates of other losses

TABLE 6: LIVESTOCK BIOMASS AND FOOD REQUIREMENTS ON AN ANNUAL BASIS IN RELATION TO NET PRIMAARY PRODUCTION, CENTRAL DISTRICTS, SOUTH KORDOFAN

| ANIMAL SPECIES | ANIMAL BIOMASS (KG/HA) | NET PRIMARY PRODUCTION (NPP) (KG/HA) | ANIMAL FOOD REQUIREMENT (KG/HA) | NPP CONSUMED (Percent) | UNBURNT NPP CONSUMED (Percent) |
|---|---|---|---|---|---|
| Cattle | 18.2 | 3620 | 162.2 | 4.48 | 6.23 |
| Sheep & Goats | 2.6 | | 33.5 | 0.93 | 1.29 |
| Camels | 2.6 | | 20.4 | 0.56 | 0.78 |
| Donkeys | 0.3 | | 2.8 | 0.08 | 0.11 |
| TOTAL | 23.7 | 3620 | 218.9 | 6.05 | 8.41 |

occurring up to the time of burning (e.g., grazing by livestock, decomposition, and consumption by small mammals and invertebrates). Figure 9 is a model illustrating the factors contributing to the loss of herbage and its availability for grazing over the year. Refinements in the model will be made following the collection and analysis of data in 1984.

Translated into potential forage for livestock at the current utilization rate of unburnt vegetation (i.e., 8.4 percent), prevention of a 30 percent loss in herbage production is sufficient to support a 43 percent increase in the biomass of livestock. In addition to causing high forage losses, the frequent incidence of burning appears to have a negative impact on the structure and composition of herbaceous vegetation. The implications of this on forage quality have already been discussed.

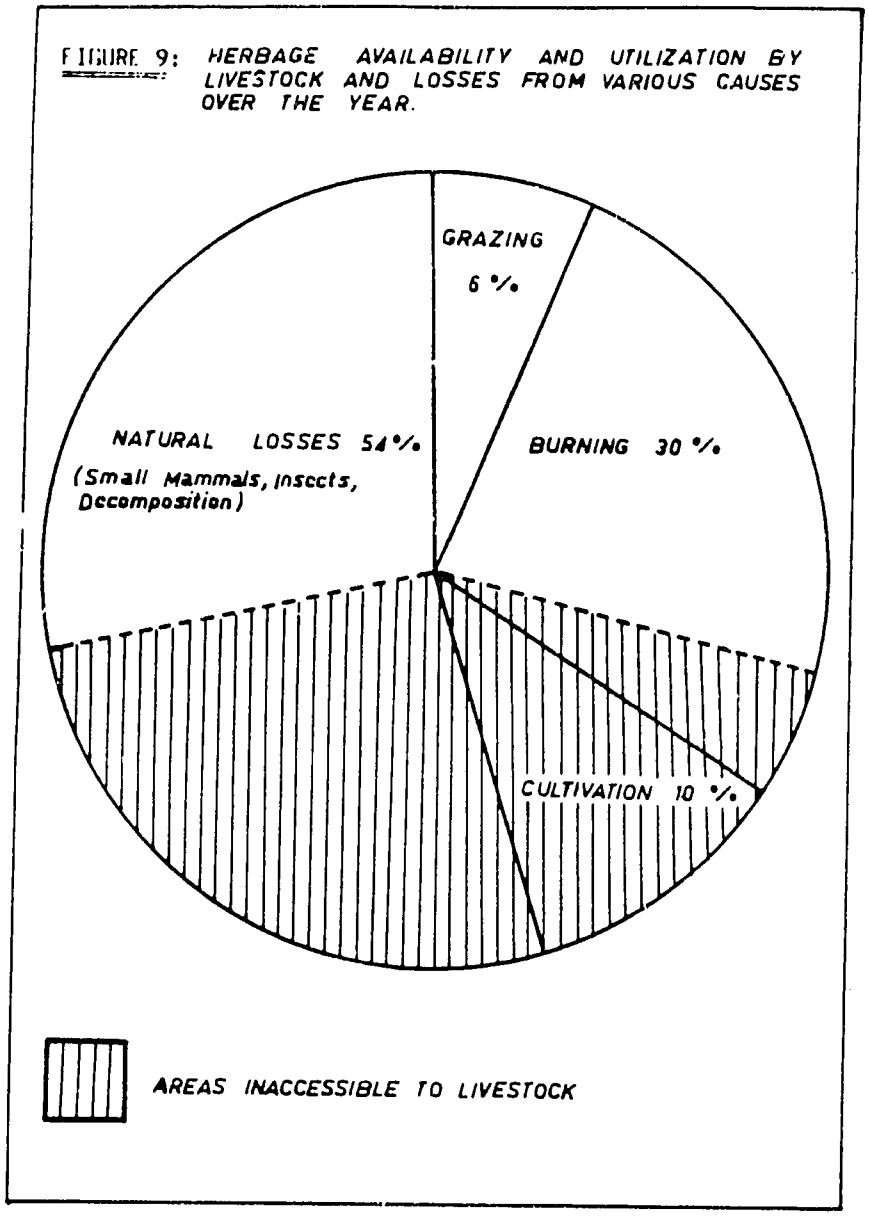



FIGURE 9: HERBAGE AVAILABILITY AND UTILIZATION BY LIVESTOCK AND LOSSES FROM VARIOUS CAUSES OVER THE YEAR.

## 2. The Seasonality and Intensity of Grazing

Approximately 70-80 percent of the livestock in the Nuba Mountains is engaged in a migration out of the area to the drier ranges of the north for a major part of the growing season. The remaining livestock are scarcely sufficient to produce any noticeable change in the vegetation at this time of year. This is due to the large quantity and rapid rate of plant production during the rains.

Most grazing, therefore, takes place during the long dry season, beginning at the end of the rains when forage declines sharply in both quality and abundance. A major implication here is that grazing is largely confined to a period when plants have either completed their life-cycle, or have entered dormancy. Since most physiological damage to plants occurs during the period of active plant-growth, detrimental effects of dry-season grazing are negligible. However, from a standpoint of animal nutrition, forage quality is critical. For this and other semi-arid regions in the world, nutritious forage is abundant for only a short period of time. Forage quality subsequently declines in value to the point where the plant material either becomes unpalatable (i.e., no longer acceptable or assimilated as food), or its nutritional content is insufficient to meet the maintenance requirements of the animal. Thus, the absence of a large portion of the livestock biomass in the Nuba Mountains during the growing season causes a loss in use of productive, palatable forage, due to structural changes which render portions of the plant inedible, following the flowering stage and dormancy. This obviously affects the food chain efficiency of livestock in terms of the proportion of the primary production consumed and the region's carrying capacity.

The importance of grazing in terms of season and intensity becomes readily apparent when comparing areas with high animal densities during the wet season. Such areas are invariably characterized by a higher utilization of the primary production, but this greater efficiency may in fact be excessive, leading to problems of resource deterioration. Studies in drier ecological zones are currently examining these relationships.

## 3. Water Availability

An obvious influence on resource utilization and livestock biomass is the seasonal distribution of water and the physical restriction it imposes on access to forage, particularly for 'water-bound' species. Water availability is widely recognized as a crucial factor in

determining range carrying capacities, and hence its frequent inclusion in livestock development programs. In most African ecosystems, water is considered the principal factor limiting the numbers and biomass of ungulate populations, and the carrying capacity of a region is reflected best by the area physically within reach of the animals present.

It is estimated that 30 percent of the rangelands in South Kordofan are unutilized by livestock, due to the absence of dry-season water. The scarcity of this essential resource leads to localized concentrations of livestock and intense competition for the available grazing. As the dry season progresses, the resulting pressure causes a steady depletion of forage in expanding arcs from the source of water. Although, as pointed out earlier, this rarely causes problems of resource deterioration (due to the dry-season pattern of grazing and nature of the environment), animals are forced to travel greater distances for food and water, resulting in higher rates of energy expenditure, and reduced food intake. For livestock, additional stress is created by the onset of the hot season which coincides with the period when the availability and quality of forage are most limiting.

The general conclusion drawn is that there is a physical barrier to the potential carrying capacity of savanna systems where free water is restricted in availability during the dry season. The implication here is that the efficiency of resource utilization in water-deficient areas is appreciably lower than those with extensive and well-distributed supplies.

## 4. The Diversity of Herbivore Species

The relative proportions of different herbivore species in a grazing system has an important bearing on the efficiency of resource utilization. It is generally acknowledged that higher carrying capacities are supported in ecosystems containing a high diversity of animal

species (i.e., a large number of species with populations of comparable biomass). This is primarily due to differences in size, feeding behavior, diet, and resource requirements between species. Animal diversity produces a more efficient, and often complementary, utilization of heterogeneous vegetation. In the Nuba Mountains, and South Kordofan in general, the livestock biomass is dominated by cattle and sheep, both of which are principally grazers, while browsing species such as camels and goats are relatively low in biomass. Apart from localized areas on specific jebels and footslopes, browsing pressures are low relative to the quantities of forage produced by woody vegetation. This is particularly evident in the vegetation of the cracking clays, in areas distant from permanent water, and in the more remote portions of jebel ranges. Given the current numbers and mix of domestic livestock, browse utilization is far below its potential.

## 5. Competitive Interactions Among Different Groups of Animals

Competition for food and other resources within and between different components of the trophic level (e.g., ungulates, small mammals, and invertebrates), is also important, since all remove a portion of the primary production, some part of which may be essential, but in limited supply to a certain species or group. Analyses of ecosystems in East Africa have demonstrated that invertebrate herbivores (e.g., grasshoppers and harvester ants) and detritivores (e.g., termites) can remove more than 50 percent of the net primary production, much of which includes plant material (e.g. green leaves) selected by large mammals. Moreover, the biomass of invertebrate populations tends to be highest in areas where the influence of grazing ungulates, such as livestock, is low. For regions such as South Kordofan, the implications of this on forage availability for livestock are clear. Thus, the overall low density of livestock in this region, coupled with the delay of most grazing until after the end of the growing season, could potentially allow the build-up and maintenance of a large invertebrate biomass. Observations on high insect populations in South Kordofan (e.g. locust swarms, grasshoppers, ants and termites) suggest support

for this pattern. Under such conditions, the competitive effects of one animal group on another can have significant impacts on the density and biomass of their respective populations.

## 6. Cultivation

Most cultivation occurs in areas which are potentially accessible to livestock, but the nature of the activity effectively precludes grazing, apart from some limited use of crop residues. Under the current system of cultivation, the extensive practice of fallowing has important implications for grazing. Areas where continuous cultivation is followed by long fallow periods are characterized by a relatively large proportion of fallow land (see Section on the Nuba Sedentary System). This adversely affects the productivity and quality of fallow grazing because the establishment and growth of desirable forage species is prevented or depressed by the disruptive influence of periodic cultivation and destructive land-clearing practices (i.e., fallow vegetation is maintained at low seral stages of succession, where plants of high forage value are low in abundance).

An improvement in the current system of cultivation through a shortening of the fallow period could result in a significant reduction in fallow land, which would permit the growth and development of better quality plants. The outcome would lead to more productive animals, as well as a more efficient and better integrated system of cropping.

# IV. LIVESTOCK RESOURCES IN SOUTH KORDOFAN

## Importance to the Region

The potential importance of Kordofan Region as a livestock producing area is considerable. According to recent estimates, (Booker, et al, 1981), 3.1 million cattle, 3.7 million sheep, 2.8 million goats, and 1.1 million camels are resident in this Region. Although livestock numbers vary within the region on a seasonal basis, during the dry season the majority of cattle are resident in South Kordofan, in addition to 0.5 million sheep, 0.36 million goats, and 0.056 million camels. Cattle represent over 90 percent of the domestic herbivore biomass in the South during this season (Hunting Technical Services, 1981).

Within South Kordofan, livestock management systems fall into one of two broad categories, depending on the mobility of the household; (1) sedentary sytems, where households are fixed and livestock spend the entire year in the Nuba Mountain Region; and (2) migratory systems, where households move with their livestock during seasonal migrations between northern and southern grazing areas in an attempt to make the best possible use of available resources, while minimizing problems of insect pests, disease, and mud. The timing and distance of these migrations vary with different producer groups. In general, for producers in the central region of South Kordofan, migration routes are shorter than for producers in other areas of the province, the period of residence in the South is longer, and herds tend to spend most of the dry season near their home area rather than undertaking long treks further South (Hunting Technical Services, 1981).

## Livestock Husbandry and Productivity

Productivity within traditional herds and flocks in South Kordofan is relatively low, and under present conditions is more a reflection of the nutritional and disease constraints limiting production than the genetic potential of the indigenous livestock. Herd demographics, particularly the low adult female; adult male herd ratios, reflect the multiple uses for adult males within traditional households and the existing economic advantage for the sale of mature 5-7 year-old males. Reproductive efficiency is also low in traditional

herds, with most breeding females calving every two years. One important factor resulting in these extended calving intervals is the absence of controlled breeding, which if improved could better match the physiological requirements of breeding animals with the seasonal availabilty of forage. Low productivity is also the result of poor growth and development of young stock, frequently due to the competition for scarce milk supplies among calves, households, and markets, which result in late maturity and delayed age at first calving.

Generally, the inability of producers to provide their animals with an adequate level of nutrition during the dry season or to effectively control disease problems make livestock production an inefficient and risky activity. Although effective vaccines exist for protecting cattle against the more important diseases found in South Kordofan, e.g. rinderpest, contagious pleuropneumonia, anthrax, and hemorrhagic septicemia, the absence of logistical support resources by the Veterinary Department makes the timely and effective implementation of vaccination programs impossible. As a result, livestock losses during the past two years has steadily increased, with rinderpest and contagious pleuropneumonia accounting for the majority of deaths. The lack of adequate field equipment has made a quantitative assessment of losses impossible. In addition, the high incidence of bovine farcy, streptotrichosis and demodex lead to premature culling, frequently of productive 7-9 year old female animals.

Inefficient utilization of the natural resource base is a fundamental problem for all livestock producers in South Kordofan. Although this region produces an abundance of forage, albeit of low nutritive value in the post-mature stage, several factors severely limit the potential utilization of the region for livestock production. These include (1) the inability and/or unwillingness of producers to cope with the physical and disease problems required for utilizing the extensive cracking clay plains during the rainy season, (2) widespread burning, which not only destroys large quantities of forage, but also promotes undesirable changes in the vegetation, (3) land-use conflicts among producer groups over scarce resources and (4) the absence or lack of an effective land-use policy for regulating the utilization of specific areas by specific groups for specific purposes.

# V. BAGGARA TRANSHUMANT SYSTEM

## Introduction

The Baggara or cattle-owning groups in South Kordofan are various branches of the Hawazma and Mesiriya tribes (for details regarding ethnic background and kinship ties, refer to Teitelbaum, 1983). Cattle are the most important livestock raised, but considerable numbers of sheep and goats are also kept. Donkeys, and in many instances camels, are used as beasts of burden along with the more traditional oxen. In addition, chickens and dogs are invariably found in transhumant camps.

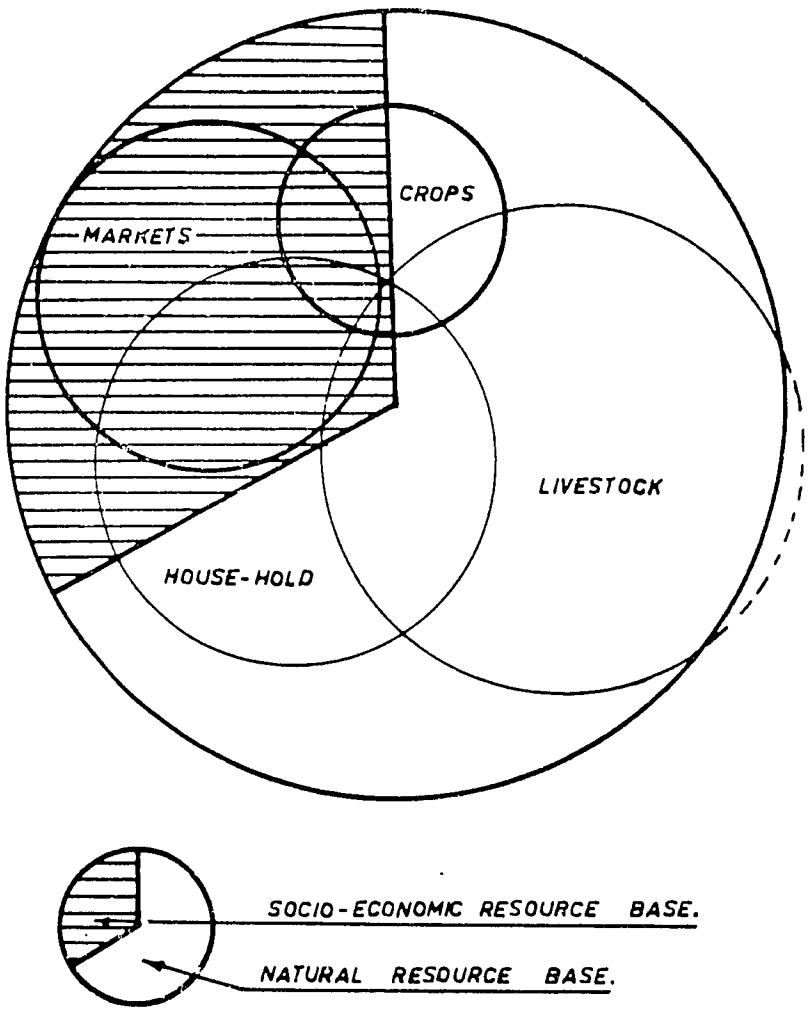
Cropping plays a relatively minor, though important, role in transhumant activities. Major crops grown include sorghum, sesame, and cotton on cracking clays, with millet and groundnuts on areas of lighter, sandier soils. In general, crops are grown for subsistence purposes to avoid the necessity of selling animals to purchase grains. However, cotton and sesame may also be cultivated as cash crops, which are then sold for basic household needs. The interactions between various system components and their dynamics are shown in Figure 10 in relation to the natural and socio-economic environment.

## System Characteristics

### Factors Associated with Migration

Transhumance basically involves a migration of varying distances to the more arid, sandier ranges of the north during the rains, returning to specific locations in the clay-dominated ranges of the south for the dry season. Here people and animals usually settle in more or less permanent camps until the start of the next rains. Actual distances travelled during migrations vary with the particular group or fariq involved. The nature of seasonal treks, for a given fariq, as well as variations in the route followed, are partly influenced by socio-economic considerations. These are discussed in more detail by

FIGURE 10: TRANSHUMANT BAGGARA SYSTEM [1]




1 Circle sizes represent the relative spheres of influence by component parts of the system. The distinction of households from agricultural activities represents decision-making, resource allocation, and various activities to fulfill other domestic needs (e.g., fuel, water, market produce). Circles falling partially outside the limits imposed by the natural resource base indicate improper or excessive land-use pressures. The natural environment ultimately determines how large a particular sphere becomes. Problems of resource deterioration and low or declining agricultural productivity can be reversed by improving management and resource utilization, decreasing the demands from specific enterprises, increasing the integration among components, and developing improved land-use policies.

Teitelbaum (1983). However, the principal factors responsible for the development and maintenance of seasonal migrations among Baggara transhumants are related to improved survivability, necessitating the adoption of a mobile lifestyle and an opportunistic exploitation of the natural resource base.

Traditionally, seasonal patterns of movement by pastoralists were essential and well-adapted responses to the availabiltiy of forage and water, changing environmental conditions, and the incidence of disease, parasites, and insect pests. Such practices were compatible with the maintenance of productive range and forage resources. Although these factors still function as constraints, recent improvements in medical and veterinary services, and in water development have led to serious imbalances between the resource base and increased land-use pressures. Environmental deterioration from the excessive and improper distribution of livestock in fragile, northern ranges has been exacerbated by expanding cultivation into areas unsuited to cropping. Escalating conflicts between various groups over land-use has created a 'tragedy of the commons' perpetuated by the absence of a management and conservation ethic toward the utilization of the natural resource base. The result is gradually undermining the stability and productivity of transhumance in its current, traditional form.

## Patterns of Resource Use During Migrations

Patterns of movement and grazing are largely determined by forage conditions and the amount, distribution, and timing of rainfall. Movement north begins shortly after the start of the rains. Although general patterns of migration usually follow traditional routes, which tend to be rather fixed in nature, the specific timing of movements and selection of areas for grazing are closely associated with the availability of water and the quality of forage. The initial departure for the north is dependent on sufficient rainfall for ephemeral surface ponds to form in areas where permanent water is absent or limited in supply. The selection of such areas is based on several factors, including:

1. availability of abundant sources of forage in areas where the lack of water precludes heavy use during the dry season,

2. access to surface water which eliminates the labor-intensive effort of watering large herds of livestock from hand-dug wells,

3. proximity to sandy or non-cracking soils to alleviate problems of mud.

In terms of grazing, cattle during the early rains depend primarily on dry grass from the previous season, since plant growth at this time lags considerably behind rainfall. However, small ruminants are able to select a diet of higher quality due to their feeding behavior and smaller size, enabling significant use of browse which develops well before the rains begin. As new grass becomes more plentiful, the proportion of dead herbage consumed by cattle drops in favor of younger, more nutritious forage.[1]

Following an initial short period for animals to regain condition, movement northward continues at the rate of about 10-20km every second or third day, although this is affected by rainfall farther north and the subsequent availability of water and adequate forage. Stops for recuperation usually occur at traditional points, frequently involving a stop of longer duration to organize the cultivation of crops on land where individuals in the fariq hold rights. Additional stops are made in areas where kinship ties are found.

Time spent on the qoz and gardud soils of the northern ecological zone[2] vary from three to eight weeks. As supplies of forage and water are depleted, the return trip south begins, usually in late September or early October. Most fariqs depart early enough to ensure the availability of sufficient grazing and water along their traditional routes.

In the southern ranges, transhumants begin arriving in mid-October. During the early dry season, grazing is concentrated in areas with ephemeral sources of water. This strategy is an attempt by individuals or groups to reserve forage

---

1 In order to satisfy bulk requirements, cattle must balance their intake of nutritious forage of high moisture content with dry grass. This is particularly important for very short, new grass at the start of the growing season.

2 Northern parts of South Kordofan and the southern part of North Kordofan

supplies around permanent water for use later in the season when the poor distribution of water limits the abundance and availability of grazing. By early or mid-December, the majority of transhumant fariqs have settled at specific locations for the remainder of the dry season, unless forced to leave for lack of forage, caused by widespread burning, or intensive grazing.

## Grazing Patterns in South Kordofan

The pattern of grazing in the south generally involves a preference, during the early part of the season for areas that are inundated during the rains. These areas contain tall perennial plants which remain green long after vegetation in other areas dries, due to residual soil moisture and their long-lived nature. However, due to their small and localized distribution, grazing in seasonal swamps is often depleted by December of January, or in some cases, is burned off due to conflicting interest (e.g. proximity to cultivated fields and the dangers of crop damage by trespassing animals).

During the cooler months from January to March, most grazing takes place on the cracking clays with considerable use of crop residues from harvested sorghum fields. The latter are rapidly used up and for the remainder of the season, grazing is concentrated on vegetation in the cracking clay plains. For cattle, most grazing at this time depends on dead grass, but significant proportions of browse are taken following the onset of the hot season, which stimulates leaf growth in woody vegetation. By contrast, small ruminants during the same period actively select high quality browse, either on the plant or as fallen leaves, flowers, fruits and pods on the ground. These animals are commonly observed foraging on burnt areas where their diet consists of fallen leaves from trees and shrubs that have been scorched by the effects of fire.[1]

## Herd Composition and Productivity of Cattle

Tables 7 and 8 summarize data collected from late December 1981 to early March 1982 on 17 herds of Hawazma cattle located in four different areas. Similar data on sheep were collected, but a larger sample size is needed before

[1] Camel herders frequently burn rangeland to stimulate new regrowth on trees for camels, and to cause leaf-drop for use by sheep and goats.

Table 7: Herd Sizes and Composition of Baggara Transhumant Cattle by Household

| Herd | 0-12 m | | 13-24 m | | 25-48 m | | | 4-6 yr | | | 7-9 yr | | | >9 yr | | | Herd |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number | F | M | F | M | F | M | C | F | M | C | F | M | C | F | M | C | Size |
| 1 | 15 | 12 | 8 | 5 | 14 | 9 | - | 38 | 14 | 11 | 10 | 2 | 3 | 3 | - | - | 144 |
| 2 | 18 | 17 | 11 | 9 | 21 | 12 | 1 | 32 | 8 | 4 | 20 | 3 | 4 | 22 | - | 1 | 183 |
| 3 | 23 | 14 | 12 | 7 | 27 | 11 | - | 59 | 12 | 10 | 37 | 3 | 1 | 24 | 4 | 1 | 245 |
| 4 | 3 | 5 | 3 | 1 | 7 | 2 | - | 5 | 4 | 5 | 10 | - | - | 7 | - | - | 52 |
| 5 | 3 | 4 | 6 | 3 | 19 | 9 | 3 | 34 | 9 | 6 | 6 | - | - | - | - | - | 102 |
| 6 | 7 | 11 | 6 | 3 | 9 | 4 | - | 9 | 3 | - | 11 | 9 | - | 40 | 1 | - | 113 |
| 7 | 5 | 4 | 5 | 5 | 7 | 9 | - | 5 | 8 | 1 | 16 | 4 | 6 | 11 | 1 | 1 | 88 |
| 8 | 3 | 7 | 2 | 1 | 3 | 2 | - | 17 | 1 | - | 5 | 1 | - | 12 | - | - | 54 |
| 9 | 12 | 8 | 7 | 4 | 10 | 4 | - | 12 | 5 | - | 8 | - | 1 | 10 | 1 | - | 82 |
| 10 | 8 | 4 | 3 | 3 | 4 | 5 | - | 15 | 6 | - | 5 | - | - | 16 | - | - | 69 |
| 11 | 4 | 3 | 2 | 2 | 4 | 4 | - | 8 | 1 | - | 3 | 1 | - | 4 | 1 | - | 37 |
| 12 | 4 | 11 | 5 | 6 | 16 | 12 | 2 | 17 | 4 | 4 | 12 | - | - | - | - | - | 93 |
| 13 | 12 | 12 | 10 | 6 | 20 | 19 | - | 43 | 14 | - | 22 | 4 | 6 | 16 | - | 1 | 185 |
| 14 | 13 | 11 | 7 | 4 | 7 | 4 | - | 16 | 4 | - | 14 | 1 | 5 | 20 | - | 1 | 107 |
| 15 | 16 | 15 | 12 | 16 | 19 | 11 | - | 25 | 8 | 3 | 39 | 5 | 6 | 9 | - | - | 184 |
| 16 | 9 | 11 | 6 | 3 | 10 | 8 | - | 22 | 11 | 2 | 26 | 5 | 4 | 7 | - | - | 124 |
| 17 | 7 | 6 | 4 | 2 | 9 | 6 | - | 15 | 7 | 1 | 13 | 2 | 2 | 3 | - | - | 77 |
| Total | 162 | 155 | 109 | 80 | 206 | 131 | 6 | 372 | 119 | 47 | 257 | 40 | 38 | 204 | 8 | 5 | 1,939 |

TABLE 8: COMPOSITION AND PRODUCTIVITY OF HAWAZMA TRANSHUMANT CATTLE

| SEX | AGE GROUP | NUMBERS | PERCENT TOTAL |
|---|---|---|---|
| Calves | < 12 months | 317 | 16.3 |
| Females | 12 - 23 months | 109 | 5.6 |
| Males | 12 - 24 months | 80 | 4.1 |
| Females | 2 - 4 years | 206 | 10.6 |
| Males | 2 - 4 years | 137 | 7.1 |
| Females | > 4 years | 833 | 43.0 |
| Females (which have calved) | > 4 years | 651 | 33.6 |
| Males (Total) | > 4 years | 257 | 13.3 |
| Castrates | > 3 years | 96 | 5.0 |
| Total Numbers | | 1,939 | |
| Number of Households | | 17 | |
| Mean Number/Household | | 114 | |

Production Characteristics

| | |
|---|---|
| Age at 1st Parturition | 4 - 5 years |
| Calfing Rate | 48.7 percent |
| Parturition Interval | 20 months |
| Number Offspring/Life Time of Breeding, Female | 3 - 6 |
| Percent Breeding Age Females | 43.0 percent |
| Percent Females (Calved) | 33.6 percent |
| Percent Breeding Age Males (Uncastrated) | 8.6 percent |
| Pre-weaning Mortality | 10 - 15 percent |
| Adult Mortality | 15 - 20 percent |
| *Annual Herd Production Index[1] | 0.2 86 |

1 Calculated by the following: $\frac{12 \text{ months}}{\text{parturition interval}}$ (percent breeding age females in herd, excluding animals under 2 years) (1 -Pre-weaning mortality)

presenting the results. All individuals were examined in each herd with the assistance of the owner, who provided details on age and breeding history. Spot checks on ages were carried out in every herd by evaluating tooth eruption and wear. The results showed that producers were extremely consistent in aging animals and they probably gave more accurate data than that possible by examining teeth.

1. Calving Rates

A striking feature for cattle in South Kordofan compared with herds in South Darfur (Wilson, 1974) is the difference in calving rates.[1]. In Hawazma herds, calving percentages were calculated at 48.7 ± 7.3 percent at the 5 percent probability level. These were based on the number of calves less than 12 months in relation to the number of adult females which had calved (i.e. no heifers of 4 years and less were included). This compares with Darfur figures of 49-50 percent, which is based on the number of calves to females of potential breeding age. Animals included in this calculation were those over 30 months of age, and although providing a ratio of calves to animals potentially capable of breeding, it does not represent a real calving rate. Application of this procedure to data collected in South Kordofan would result in a calving rate of 38 percent simply because it would include a large number of heifers which had never calved. Informal interviews with a large sample of transhumants indicate that the age at first calving is 4-5 years, which agrees with data presented here on Hawazma cattle, as well as reports by Wilson (1974) of similar interviews in South Darfur.

2. Calving Intervals

The Kordofan Hawazma calving rate of 48.7 percent with an estimated mortality of 12.5 percent (see RMR, 1975 and Sentinel Herds, this report), yields an approximate calving interval of 20 months, which is

1 In a later publication, Wilson (1976), using the same data, distinguishes between migratory and sedentary cattle, and calculates a calving rate of 60

not significantly different from the 18 month interval quoted for South Darfur (Wilson, 1976), or those for pastoral herds elsewhere in Africa.

3. Female: Male Ratios

Although overall female:male ratios are virtually identical (7:3) for both Darfur and Kordofan, a major difference is the ratio of adult females to adult males. This is 5:1 in Darfur, compared with 3.2:1 in Kordofan. The latter reflects a high percentage of both castrated and non-castrated animals which basically serve the purpose of a "walking bank" for use when the necessity arises. The desire to keep male animals at older ages is due primarily to the much higher price obtained for older adults relative to younger stock. Large oxen, in particular, are known for bringing high prices in the animal markets. These animals are also valued for their size, walking ability, leadership, riding characteristics and function as beasts of burden.

## The Seasonal Aspects of Productivity in a Migratory and a Sedentary Sentinel Herd

This portion of the Range-Livestock research program at the Kadugli Research Station has three main objectives:

1. To study the biological factors that perpetuate transhumance among the Baggara.

2. To study the performance of Baggara cattle under traditional migratory conditions.

3. To increase the time livestock spend in South Kordofan with the aim of releasing the pressure during the growing season from an already degraded Northern Kordofan.

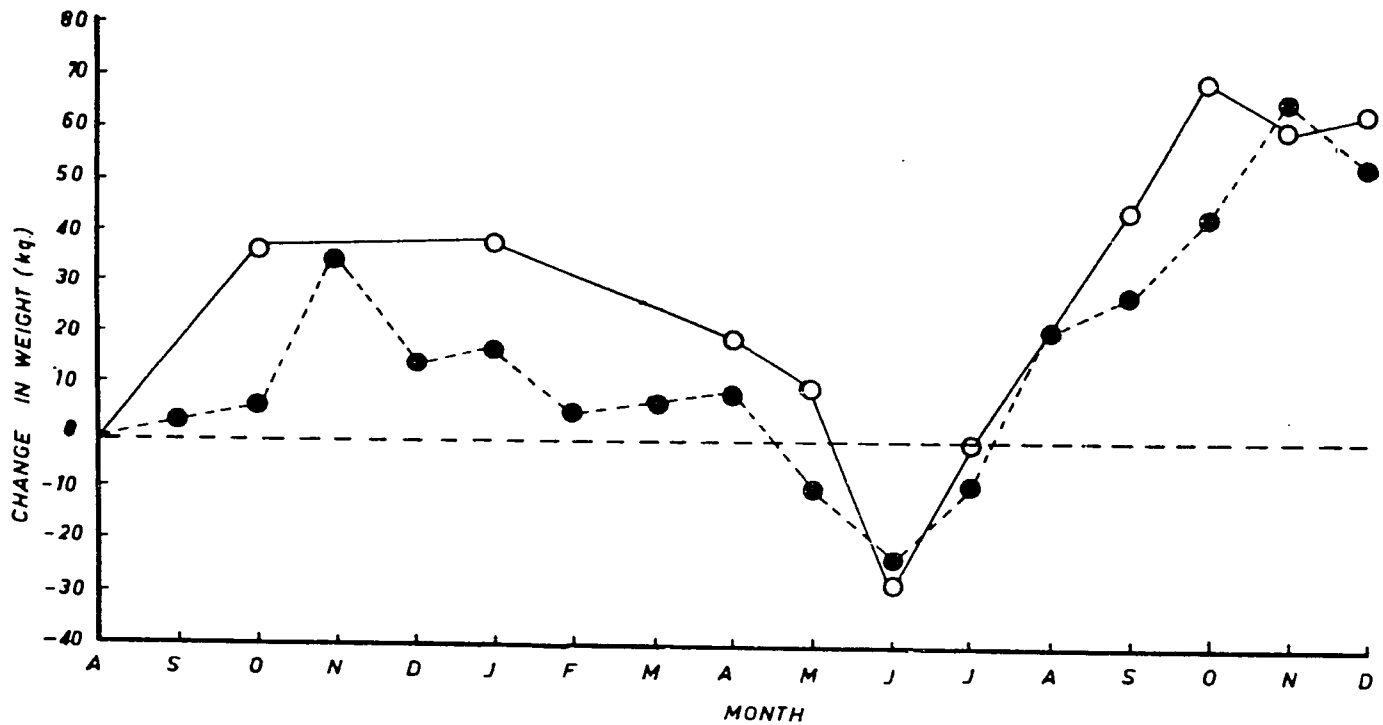
Disease and mud are frequently cited as the main factors that force migration to North Kodofan during the rainy season. The study reported here attempts to list the validity of this hypothesis. Although some studies were undertaken with cattle from Western Sudan, these almost exclusively involved cattle that were supplementary fed. The productivity of Baggara cattle under their natural environment and system of management was not investigated. We try to fill in this gap by providing information on the performance of these cattle under the transhumant system of management.

As stated elsewhere in this report, the pressure on the rangelands of North Kordofan is great during the short growing season. This led to increasing environmental degradation, as the plants are grazed before they set seeds. We feel that if factors forcing migration are elucidated and controlled, this may release pressure from these deteriorated ranges by providing an alternative for those transhumants who wish to spend more time in South Kordofan to do so.

To meet these objectives, the Kadugli Research Station bought a hundred head of cattle in August, 1982. These were divided into two herds, with a composition similar to that of traditional herds. One of these herds was managed like any traditional transhumant herd (migratory herd). The other was kept year-round on the cracking clays of the Kadugli Research Station (sedentary herd). The latter herd grazed in a fenced area of about 1,811 acres, with water provided inside the fence (except for the dry season of 1983 where the animals were driven to water in the seraf site, about 8km away). No other soecial treatment was given. Data are being compiled from the two herds on changes in weight, service, return to oestrus, abortions, calvings, milk yield and incidence of disease.

Figure 11 shows the changes in weight of the two herds during the period August 1982 to December 1983. Results are expressed as change from the weight of animals during August 1982. Maximum weight was reached by November. Animals then started to lose weight steadily during the dry season, to a minimum in June.

FIGURE 11: CHANGES IN WEIGHT OF THE MIGRATORY (○) AND SEDENTARY (●) HERDS (AUG. 1982 TO DEC. 1983)



Animals under three years of age appear to lose less weight during the dry season than do mature females (Figure 12). Preliminary observation suggests that this could be because most mature females were either in late pregnancy or were lactating, which greatly increased their nutrient requirements compared with growing animals.

Data collected during the dry season (January-June) and rainy season (June-October) of 1983, were then subjected to regression analysis in turn (See Figure 13, a. b,) with the aim of estimating daily weight gains. A linear negative relationship was observed in both herds between weight and advance of the dry season. The following regression equations were calculated:

$$y = 241.9 - 0.367x \quad (r = 0.88) \text{ migratory}$$
$$y = 216.6 - 0.227x \quad (r = 0.90) \text{ sedentary}$$

The slopes of the lines described by these equations indicate a weight loss of 0.367 and 0.227 Kg/day for the two herds, respectively.

On the other hand, a linear positive relationship was found between weight gains and advancement of the rainy season. The regression equations were:

$$y = 171.8 + 0.794x \quad (r = 0.999) \text{ migratory}$$
$$y = 176.5 + 0.562x \quad (r = 0.978) \text{ sedentary}$$

These equations indicate daily weight gains of 0.794 and 0.562 Kg/day, which are significantly different ($P < 0.01$).

The fact that the sedentary herd lost less weight during the dry season than the migratory herd is a reflection of better grazing inside the research farm, which is protected from trespassing animals and fires. The distance travelled in search of grazing and water is also shorter (6-8Km) compared with the migratory herd (15-24Km).

FIGURE 12: SEASONAL WEIGHT CHANGES OF MATURE COWS COMPARED TO GROWERS (2-3 YEARS)

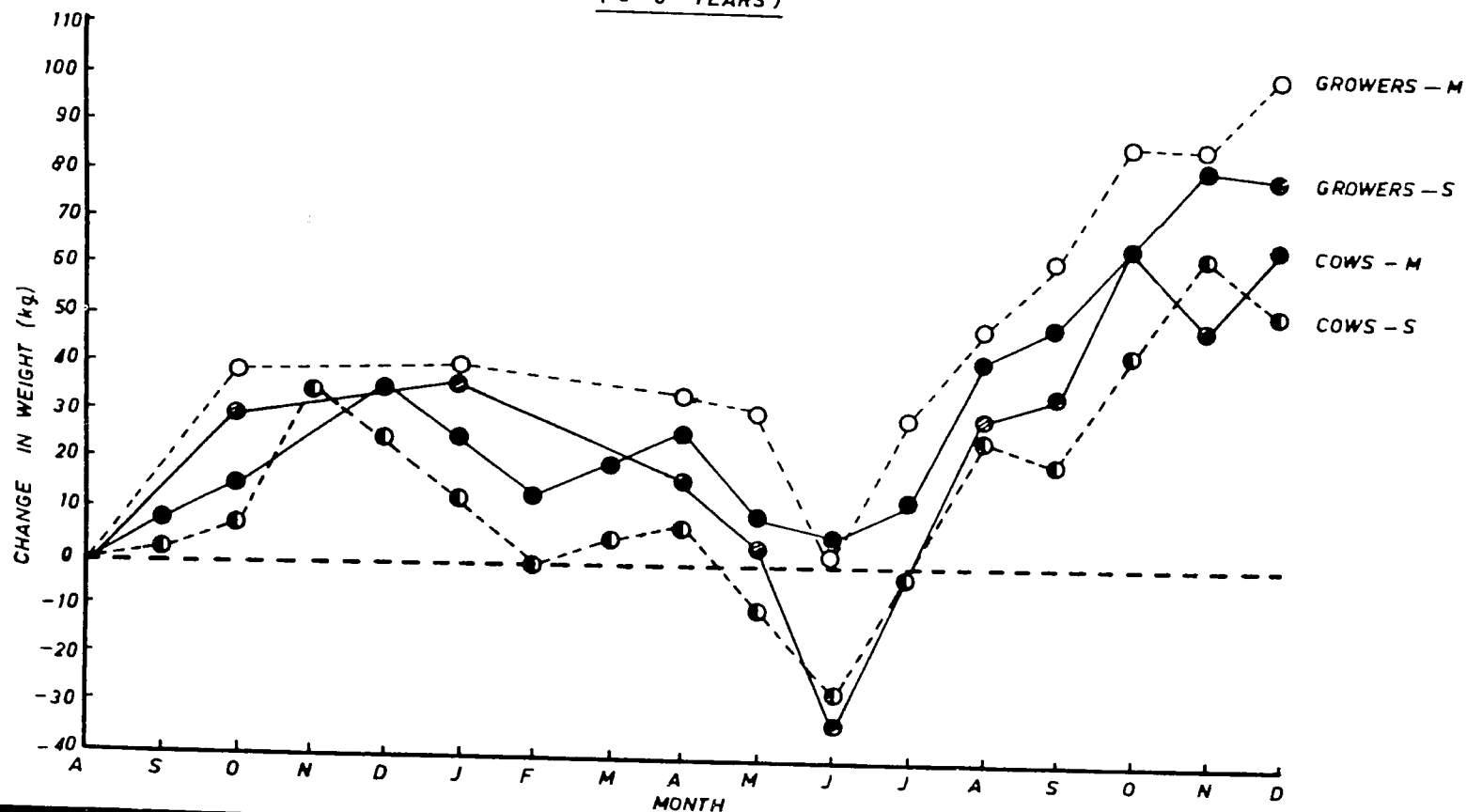
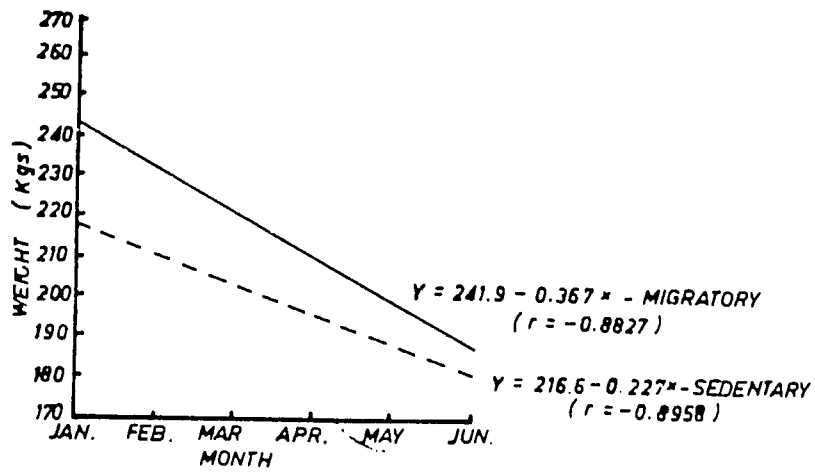
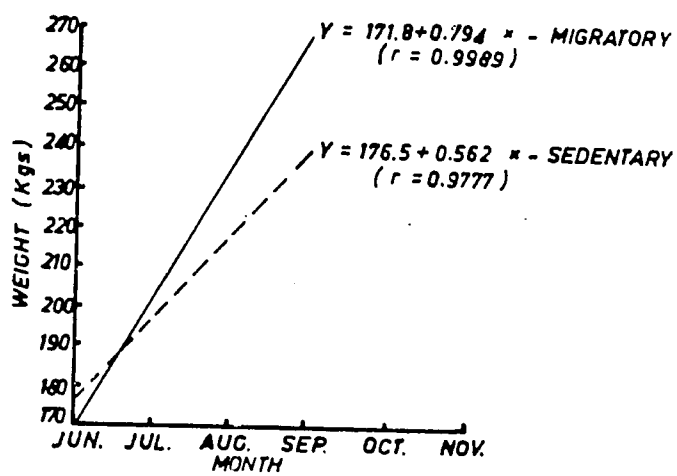


FIGURE 13:

(a) WEIGHT CHANGES OF MIGRATORY AND SEDENTARY HERDS DURING DRY-SEASON 1983




(b) WEIGHT CHANGES OF MIGRATORY AND SEDENTARY HERDS DURING RAINY-SEASON 1983






F 05

During the rainy season the migratory herd made more rapid gains than the sedentary herd. This is due to its mobility, which enabled it to reach green grazing wherever available, as soon as the early rains started. Preliminary data are being collected on other aspects of production and will be discussed in a later report.

## Seasonal Impact of Disease on Cattle Productivity in South Kordofan

A fundamental problem facing livestock producers in South Kordofan is the rapid rate of environmental deterioration occurring in traditional, northern grazing areas which is resulting in increased pressures on southern ranges for both crop and livestock production. Within these southern areas there exists an excellent potential to increase both crop and livestock production, but much of the area is unsuitable for year-round habitation by either people or livestock. Dry-season exploitation of these areas is limited by the availability of water, while rainy-season use is restricted by the physical limitations posed by mud and the high incidence of parasites and disease.

The present study was designed to evaluate seasonal disease problems impacting on cattle managed under either traditional migratory conditions or sedentary conditions requiring year-round maintenance on the cracking clays. The objective of the study was to identify important disease problems limiting cattle production on the cracking clays in South Kordofan and then design effective, strategic health programs which could be implemented by producers themselves to improve their productivity and utilization of range resources in the South. Ultimately, the adoption of such interventions should lessen the seasonal grazing pressures which are contributing to the deterioration of northern ranges by extending traditional grazing periods in the South.

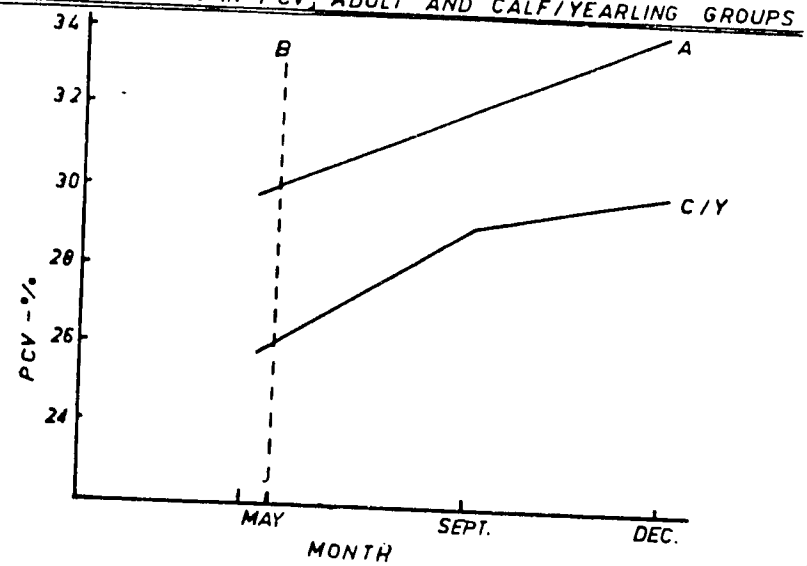
For this study, 25 adult, female cattle (5-8 years old) and 10 calves/yearlings (9-20 months old) from a migratory and sedentary herd were sampled during the months of June, September, and December, 1983, and will be sampled in March, 1984. Samples taken included EDTA and clotted blood, feces, and specimens of

ecto-parasites. Animals were routinely examined for obvious clinical problems, e.g., farcy, streptothricosis, and demodex, and an empirical assessment of ecto-parasitic burden was made.

1. Packed Cell Volume (PCV): Packed cell volume has been used as a non-specific indicator of general animal condition, and low PCVs have been correlated with the severity of gastro-intestinal parasitism, of chronic parasitic disease, of nutritional deficiencies, and of hemoprotozal disease (Schalm et al, 1975). Figures 14 and 15 illustrate the seasonal changes in PCV for both the migratory and sedentary herds, PCVs differ significantly ($p < 0.5$) between herds and between age groups ($p < 0.01$) within herds. In both herds, PCVs were at their lowest during the late dry season (May/June sampling), rising steadily during the rainy season (September sampling), and then increasing, but at a slower rate, during the early dry-season (December sampling). Throughout this sampling period, young, growing animals had significantly lower ($p < 0.01$) PCVs than did adult animals (Figure 14). Adult cattle had clinically normal PCVs throughout the sampling period, while late dry-season values for young stock in several cases (3 out of 10 in the migratory herd, and 5 out of 10 in the sedentary herd) reflected a marginal anemia (PCV = 22-24). The time-course response of PCV to improved grazing during the rainy season was not significantly different between age groups within a given herd, but was significantly higher ($p \leq 0.05$) for the sedentary herd such that by the end of the early dry season, the sedentary herd had a significantly higher ($p \leq 0.05$) mean PCV/values. In general, PCV values reflected a greater level of stress in the young stock of both herds. One possible reason for the apparent difference between herds might have been related to the unique management system of the sedentary herd on the research station farm where there was an abundance of forage throughout the year, albeit of low nutritional value during the dry season, and an easily accessible source of water. These two factors undoubtedly lowered the stress and energy expenditure associated with walking between sources of available water and forage which occurred with the migratory herd during the late dry season.

FIGURE 14:

SEASONAL VARIATIONS IN PCV, ADULT AND CALF/YEARLING GROUPS



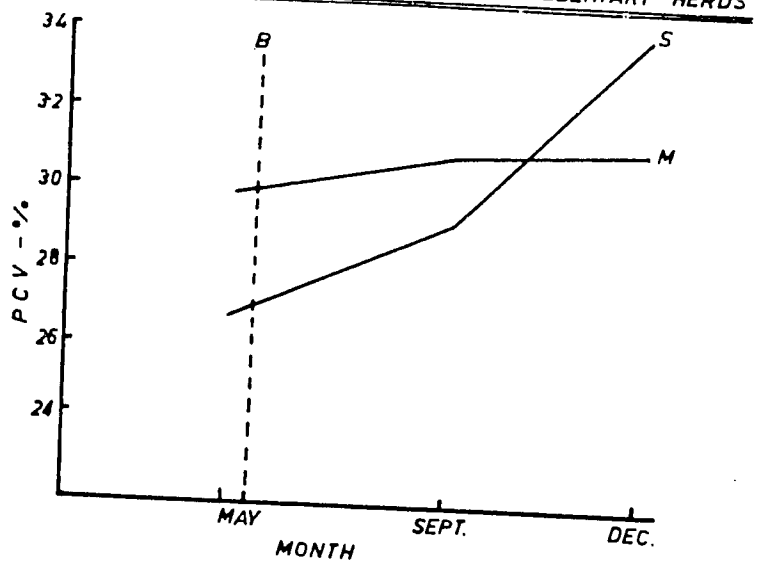

A — ADULT FEMALE ANIMALS

C/Y — CALF/YEARLING ANIMALS

B — COMMENCEMENT OF FIRST RAINS

FIGURE 15:

SEASONAL VARIATIONS IN PCV, MIGRATORY AND SEDENTARY HERDS




S — SEDENTARY HERD

M — MIGRATORY HERD

B — COMMENCEMENT OF FIRST RAINS



F 05

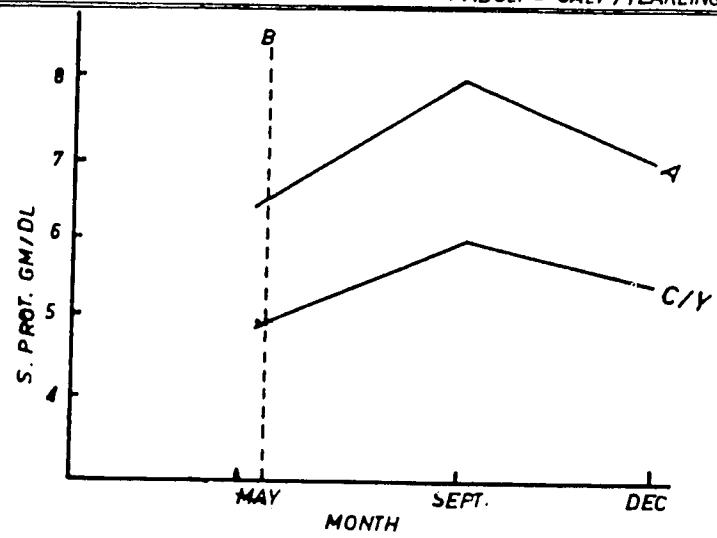
2. Plasma/serum protein: Total plasm and serum protein levels have also been used as non-specific indicators of general animal condition. In addition to their correlation with certain disease states (Yakoob et al, 1983; Tobel, 1978; Schlam et al, 1975; Ballarina et al, 1972), total plasm and serum protein levels have been used to estimate the nitrogen balance of yearling cattle (Kumar et al, 1978) and adult grazing cattle (Boudergues and Calvet, 1972). Figures 16 and 17 illustrate the seasonal changes in total serum protein levels for both experimental herds. (Plasma protein levels parallel these values.) Late dry season and rainy season values did not differ significantly between herds, although calf-yearling groups had significantly lower ($p < 0.01$) levels than did adult animals in the same herd.

In addition, all animals in the migratory herd showed a more rapid decrease in total serum protein levels during the early dry season than did animals of a similar age-group in the sedentary herd. This rapid decline in serum protein levels in the migratory herd may be a reflection of the marked difference in forage quality between rainy and dry season grazing areas.

Preliminary estimates of nitrogen-balance in the two calf/yearling groups were calculated using a regression analysis developed by Kumar et al, (1978), utilizing total plasma protein values. As illustrated in Figure 18, both calf/yearling groups were in a positive nitrogen balance throughout the sampling period. During the late stages of the dry season, animals were injesting an estimated 60-65 percent of their digestible crude protein requirement, which increased to approximately 90 percent and 75 percent respectively, for the migratory and sedentary animals during the rainy season. Significant differences were found in the time-course response of nitrogen retention ($p < 0.01$) between the calf/yearling groups, with the more rapid rise in the case of migratory animals possibly reflecting the superior quality of forage available in northern grazing areas. There was no significant difference between herds in nitrogen retention by the end of the early dry season (December sampling).

FIGURE 16:

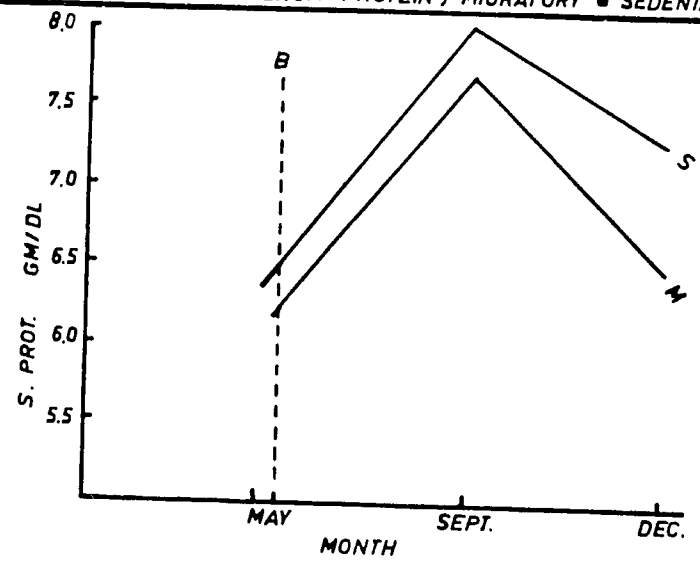
SEASONAL VARIATIONS IN SERUM PROTEIN, ADULT & CALF/YEARLING GROUPS




A - ADULT, FEMALE ANIMALS
C/Y - CALF/YEARLING ANIMALS
B - COMMENCEME OF FIRST RAINS

FIGURE 17:

SEASONAL VARIATION IN SERUM PROTEIN, MIGRATORY & SEDENTARY HERDS



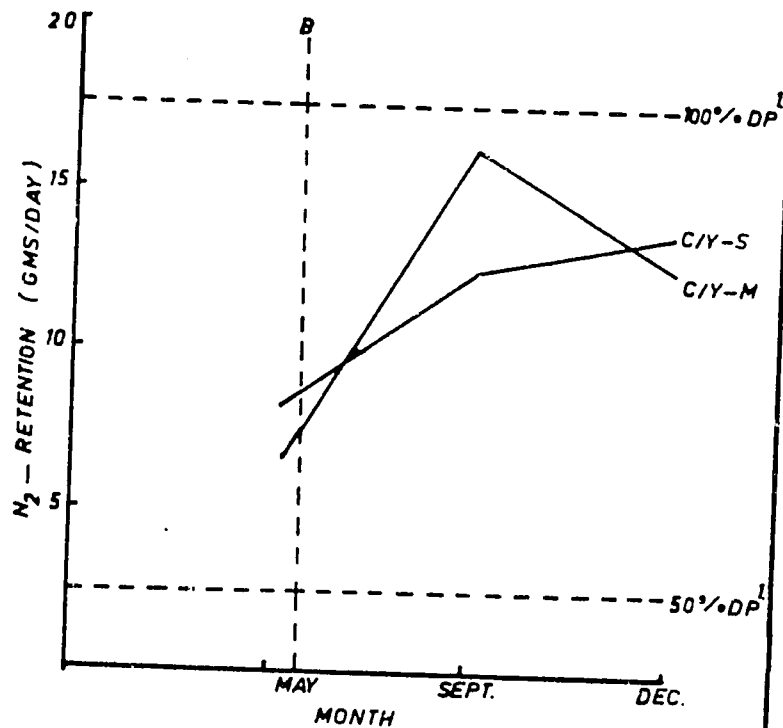

S — SEDENTARY HERD
M — MIGRATORY HERD
B — COMENCEMENT OF FIRST RAINS



F 05

FIGURE 18:

SEASONAL VARIATIONS IN NITROGEN RETENTION AND DIGESTABLE PROTEIN INTAKE FOR CALF/YEARLING GROUPS




1 – DIGESTABLE PROTEIN, 50% REQUIREMENT, 100% REQUIREMENT, (KUMAR ET AL., 1980)

C/Y-S – CALF/YEARLING GROUP, SEDENTARY HERD.

C/Y-M – CALF/YEARLING GROUP, MIGRATORY HERD.

B – COMMENCEMENT OF FIRST RAINS.



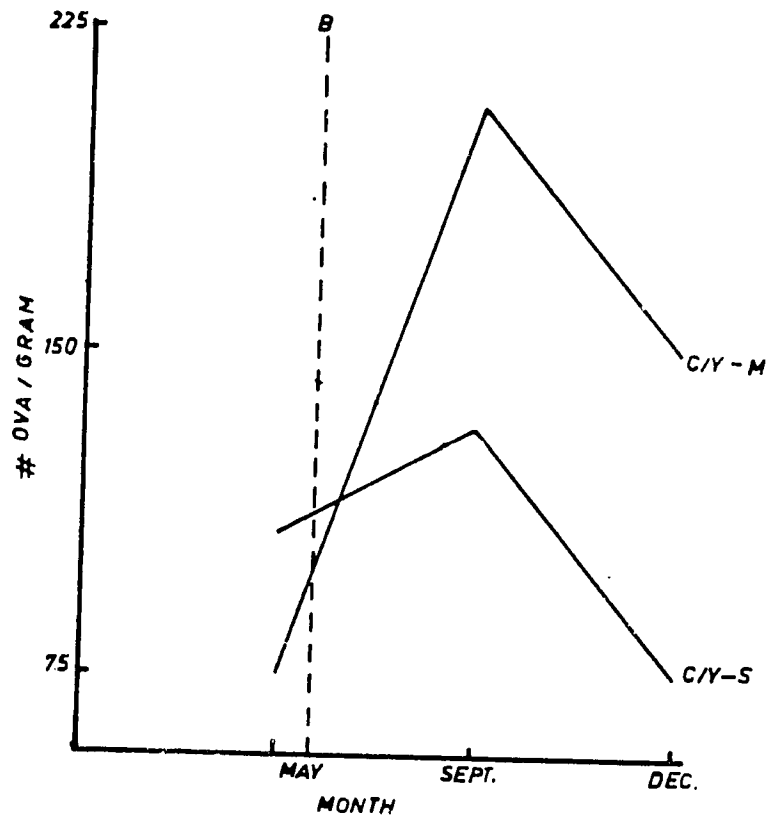
F 05

3. Parasitic infestations: Because of the climatic requirements for the maintenance and build-up of infective larval populations on range, sufficient to pose a significant threat to grazing livestock, the incidence of clinical parasitic infestations in South Kordofan would be expected to follow a distinct seasonal pattern. An exception might be expected in those cases where use of permanent sources of water for livestock could provide for the rapid build-up of larval populations as the result of high livestock densities and/or intensive grazing by mixed-ruminant populations. During the present study, dry season watering for the sedentary herd took place at a public watering point which was utilized by many producers during the season. In the case of the migratory herd, both early and late dry-season watering and grazing utilized areas frequented by thousands of migratory and sedentary livestock.

During the course of this study, fecal egg counts for all experimental groups were less than 400-500 ova/gram of feces, below a level considered indicative of clinical helminthiasis (Wilson, personal communication). Figure 19 illustrates the seasonal variation in ova counts for composite fecal samples for calf/yearling groups. In both groups the late dry season counts were at a subclinical level, but were significantly higher ($p < 0.05$) in the sedentary calf/yearling group than the comparably aged migratory group. (It should be noted that 3 calves in the sedentary group were both marginally anemic, PCV = 22-24, and hyporotenemic, total plasma protein less than 5.0 gms/dl, during this period.) During the rainy season, the level of shed ova increased at a significantly higher ($p < 0.01$) rate in the migratory herd, peaking in both groups during the late rainy season and then decreasing during the early dry season. Although uncomplicated cases of clinical helmenthiasis were not routinely diagnosed in our experimental groups, this condition does occur in traditional herds in South Kordofan and is quite common in traditional flocks of sheep during this period. Under traditional management conditions, the likelihood of cross infection among species should be considered. Gastrointestinal helmenthiasis does not appear to be a significant production constraint in adult cattle, although it may play a role in limiting the performance of young stock

FIGURE 19:

SEASONAL FECAL OVA COUNTS FOR CALF/YEARLING GROUPS




C/Y-M — CALF/YEARLING GROUP, MIGRATORY HERD

C/Y-S — CALF/YEARLING GROUP, SEDENTRRY HEARD

B — COMMENCEMENT OF FIRST RAINS



F 05

during the late dry season when animals are severely compromised by nutritional stress. The seasonal pattern of fecal ova counts illustrated in Figure 19 offers the opportunity to reduce helminth burdens and possibly improve the productivity of young stock by applying a single strategic drenching during the mid dry season, combined with some modifications in traditional management practices for both young stock and sheep, e.g., rotation of zaribas (temporary corrals).

Although quantitative studies on the season level of external parasitic infestations (ticks, lice, and mites) were not carried out, tick infestations represented a serious management problem in both herds throughout the year. Tick burdens appeared higher during the rainy season than at other times; higher in sedentary animals than migratory animals; and higher in adult, female animals than in young stock. Several genera of ticks were identified on animals in both herds, with *Hyalomma spp.* the most frequently observed, although *Ambylomma spp.* and *Boophilus spp.* were also found. The most important impact of these infestations appeared to result from the generalized irritation, blood loss, and predisposition to secondary infection and attack by biting flies. Hoogstrall (1956) implicates *Amblyomma variegatum* as a biological vector of norcaradiosis, bovine farcy, a serious disease problem in adult cattle in South Kordofan. However, the potential threat from hemoprotozal disease appears to be low throughout the year (see following section), either the result of a low level of natural challenge in South Kordofan and/or high level of natural immunity. This fact, coupled with the seasonal variations in infestation levels could facilitate the implementation of seasonal tick (external parasite) control measures aimed at reducing parasitic burdens. Such measures would also assist in reducing the level of biting flies which reach high densities on the cracking clays during the rainy season, and have, as well, been implicated in disease transmission.

4. Hemoprotozoal disease:

As mentioned in the previous section, the incidence of hemoprotozal disease was low in all experimental groups. Reference to Table 9 shows that the most common hemoparasite encountered was *Anaplasma marginale*, which

*TABLE 9:*

**SEASONAL HEMOPROTOZAL DISEASE INCIDENCE FOR SEDENTARY AND MIGRATORY HERDS**

| Sentinel Herd | Age Group | Anaplasmosis | | | T. theileria | | | Babesiosis | | | Microfilaria | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | May | Sept. | Dec. | May | Sept. | Dec. | May | Sept. | Dec. | May | Sept. | Dec. |
| Sedentary | Adults | 6/25 | 7/25 | 0/25 | 2/25 | 0/25 | 5/25 | 0/25 | 0/25 | 0/25 | 4/25 | 0/25 | 0/25 |
| | Calves/ Yearlings | 1/10 | 3/10 | 0/10 | 0/10 | 0/10 | 0/10 | 0/10 | 0/10 | 0/10 | 0/10 | 0/10 | 0/10 |
| Migratory | Adults | 9/25 | 5/25 | 0/25 | 0/25 | 0/25 | 0/25 | 0/25 | 0/25 | 0/25 | 0/25 | 1/25 | 0/25 |
| | Calves/ Yearlings | 0/10 | 0/10 | 0/10 | 0/10 | 0/10 | 0/10 | 1/10 | 1/10 | 0/10 | 0/10 | 1/10 | 0/10 |

occurred almost exclusively in adult animals during the late dry season and early rainy season. No clinical cases of anaplasmosis were diagnosed in either herd during the course of this study, and in those cases where anaplasma bodies were detected, parasitemias were less than 2-3 percent. Babesia bigemina was diagnosed in several animals of the migratory, calf/yearling group, all animals being asymptomatic. Only one case of babesiosis was diagnosed, and that was in a 12-month-old, spleenectomized, sentinel calf which was managed with the sedentary herd. The low incidence of hemoprotozal disease apparent in these two herds indicates that interventions focusing on tick control should be aimed at reducing overall tick burdens and not eliminating infestations which could reduce the level of acquired, natural immunity.

5. Animal losses: Animal losses were the highest in the sedentary herd; 25 percent, as compared to 16 percent in the migratory herd. Table 14 (p. 82) summarizes herd losses. In general, the greatest number of losses resulted from malnutrition complicated with anaplasmosis, streptothricosis, or farcy, in the case of the sedentary herd; and malnutrition complicated with management problems, e.g., dystocia, gastrointestinal foreign body, fractures, in the case of the migratory herd. Seasonally, most losses occurred just prior to, or at the commencement of the rains (see Table 10).

## The Nutritional Status of Cattle Grazing on Cracking Clay Soils

This is a preliminary investigation of the nutritional factors affecting the productivity of cattle grazing year-round on cracking clays. Factors receiving particular emphasis are:

a. Seasonal variation in diet quantity and quality.

b. Seasonal diet composition.

c. Type and extent of nutrient deficiency and how these vary with season.

TABLE 10:

Animal Losses for the Sedentary and Migratory Herds, Jan. - Dec., 1983

| HERD | AGE/SEX GROUP | DISPOSITION NUMBER () | COMMENTS |
|---|---|---|---|
| Sedentary | Adult, female | died (7) | 2/7 - uncomplicated malnutrition<br>4/7 - malnutrition + anaplasmosis (2)<br>" + streptotrichosis (2)<br>1/7 - suspected CBPP |
| | | culled (3) | 1/3 - streptotrichosis + bovine farcy<br>1/3 - streptotrichosis + anaplasmosis<br>1/3 - streptotrichosis + mastitis |
| | Adult male | died (3) | 1/3 - malnutrition + streptotrichosis<br>1/3 - humeral fracture, euthanasia<br>1/3 - traumatic pericarditis |
| | Calf, | died (1) | 1/1 - malnutrition, mastitic dam |
| | Total Losses 14/57 = 25% | | |
| Migratory | Adult, females | died (5) | 3/5 - malnutrition<br>1/5 - rumen foreign body (leather sack)<br>1/5 - dystocia, dead calf, Foot & Mouth |
| | | culled (2) | 2/2 - bovine foacy + infertility |
| | Adult, males | died (1) | 1/1 - femoral fracture, euthanasia |
| | Calf, male | died (1) | 1/1 - malnutrition, mastitic dam |
| | Total Losses 9/56 = 16% | | |

Data in Table 11 was obtained from 5 bullocks during the months of June, September and December, 1983. The diet selected by these animals during these months had a crude protein content of 5.9, 11.7 and 8.2 percent, respectively. This amounted to 264, 621, and 518g of crude protein per day. It appears that during late dry season, the intake of crude protein barely meets the maintenance requirements of these animals which were kept on the research farm. Under natural conditions, distance travelled is longer and grazing is more scarce, which means that the maintenance requirements may never be met.

The table also shows that the voluntary intake of dry matter (DM) at these three periods was 4472, 5311 and 6318 g/d respectively. As percent of body weight, 8W, this amounts to 2.8, 2.5 and 2.7 percent.

These results led to the initiation of a similar study with the station's migratory herd. It is hoped that the information collected will be more relevant to natural conditions where, at least during the dry season, distances travelled increase tremendously and the availability of grazing is in severe shortage, as the result of fires and crowding near permanent watering points.

## VI. THE NUBA SEDENTARY SYSTEM

### Introduction

The Nuba Mountain region is located in the central part of South Kordofan, which occupies approximately 138,000 $km^2$ in the wetter and more productive portion of the project area (see Table 1 and Figure 3). The rural population of the province exceeds 1.1 million people and contains a livestock population of 1.9 million cattle, 0.9 million sheep, and 0.8 million goats (Booker, et al., 1981). In terms of project goals and objectives, the Nuba Mountain region is important for several reasons. In addition to being a major crop-producing area,

Table 11

VOLUNTARY INTAKE OF FORAGE BY CATTLE GRAZING ON CRACKING CLAY

| Month | June | September | December |
|---|---|---|---|
| Number of Animals | 5 | 5 | 5 |
| Mean Body weight (Kg) | 166 | 211 | 237 |
| Crude protein content (%) | 5.9 | 11.7 | 8.2 |
| Nylon bag digestibility (%) | 59.6 | 65.3 | 56.6 |
| Voluntary intake of DMs | | | |
| g/day | 4472 | 5311 | 6318 |
| g/kg BW 0.75 | 98.2 | 94.4 | 103.6 |
| Kg/100 Kg BW | 2.8 | 2.5 | 2.7 |
| Voluntary intake of Digestible DM | | | |
| g/day | 2665 | 3468 | 3576 |
| g/Kg BW 0.75 | 57.6 | 62.6 | 59.2 |
| kg/100 Kg BW | 1.6 | 1.6 | 1.5 |
| Intake of crude protein | | | |
| g/day | 264 | 621 | 518 |

particularly for sorghum and cotton,[1] the region is resident to a rural population of over 5000,000 at a density substantially higher than any area of comparable size in Western Sudan (HTS, 1981). The Nuba Mountains are also utilized by large numbers of sedentary and migratory livestock with over 500,000 cattle, 250,000 sheep, and 400,000 goats, and contain some of the most productive rangeland in the west. Moreover, because of its strong crop and livestock component, as well as its productive resource base, the area offers high potenteial for improving the integration of crops and livestock, and hence the productivity and stability of agriculture in traditional households.

[1] Most cotton is currently cultivated on Government mechanized schemes. In traditional producing areas, cotton has been largely replaced by sorghum and sesame, due to their relative higher rates of price increases.

While these factors played an important role in the selection of the region for research, the initiation of FSR&D activities in the Nuba Mountains was also based on the existence of a functional project research station, and the availability of a relatively large body of information on the region's physical environment and cultivation patterns, although little was known about livestock productivity and the related aspects of range ecology.

## System Characteristics[1]

The collation and analysis of secondary sources of information were augmented by extensive reconnaissance surveys designed to establish recommendation domains on the basis of homogeneous characteristics, and to identify important constraints to production.

The rural population of the region is dominated by various tribes collectively known as the Nuba, which include several groups originating from southern Sudan. There is also an increasing tendency for sedentarization and cultivation among Arab groups. However, strong differences in the location and ethnic backgrounds between Nuba and Arab groups reflect major distinctions in household organization and in the allocation of resources for crop and livestock activities. The discussion will therefore be confined to the recommendation domain represented by the Nuba sedentary system of production.

Agricultural activities within the traditional sector of the Nuba are centered on cultivation, although livestock form an important component, particularly for investment opportunities and diversification of risk in years of low rainfall. The household is basically the residence of a nuclear family composed of a married couple and their off-spring. Households typically consist of a ring of huts which are attached by a common wall with a roofed or open-air compound in the center. The huts and compound are generally separated into sleeping quarters for different age and sex classes of the family. Individual huts are also used for kitchens, granaries, hand-grinding mills for flour, and as housing for young livestock, particularly kid goats and pigs.

1 For descriptions of the physical and ecological characteristics of the environment, refer to the appropriate section presented earlier.

## Crop Production

The cultivation of crops is based on a bush-fallow system which focuses on sorghum as the principal field and food crop. Households generally cultivate in several localities. These most commonly include (1) house gardens where early-maturing varieties of sorghum are grown with maize, millet, and small quantities of kurkade, okra, red pepper, tomatoes, melons, and gourds, (2) hillside and footslope plots, often called near farms, where single stands of groundnuts are cultivated, as well as longer-maturing varieties of sorghum, frequently intercropped with sesame or cowpeas, and (3) far farms, almost invariably located on cracking-clay plains where most of the late-maturing sorghum is cultivated with cowpeas as an intercrop, along with mixed or sole crops of sesame, and occasional pure stands of cotton. Many of the crops grown are used for both home consumption and for cash, with sesame, groundnuts, and cotton representing the major cash crops. Cropping activities are principally the responsibility of adults, who often form reciprocal work parties in times of intense labor demands, while children and adolescents are charged with household chores and the herding of livestock. Details of cultivation practices and the location of crops grown in relation to the household and the distribution of soils are summarized in Table 12.

Nuba patterns of property inheritance involve both patrilineal and matrilineal systems depending on the tribe in question. Although the Government of Sudan holds residual rights to all unsurveyed and unregistered land, a rudimentary system of land tenure exists, which is primarily usufruct in nature. Heritable-use rights to cropland can be claimed by individuals as long as the crop-fallow system of cultivation is maintained. In areas with plentiful land, usufructory rights can be acquired simply through land clearing. For regions with limited land resources, use rights can be rented, purchased, borrowed, or obtained as gifts.

TABLE 12: AGRONOMIC CHARACTERISTICS OF THE NUBA SEDENTARY SYSTEM

| CHARACTERISTICS | HOME GARDENS | NEAR FARMS | FAR FARMS |
|---|---|---|---|
| TOPOGRAPHY AND SOILS | Footslopes/hillsides of sandy clays and loams located adjacent to the household or its periphery | Footslopes/hillsides of sandy clays and loams located generally less than 1-2 km away | Plains of primarily cracking clays with use of some non-cracking clays. Located 1-10 km away, commonly 5 km |
| CROPS RAISED | Early-season Sorghum<br>Maize Red Peppers<br>Millet Tobacco<br>Okra Tomatoes<br>Squash Melons<br>Kerdede | Medium-maturing sorghum<br>Sesame* (mixed/sole crop)<br>Cospeas* (intercrop)<br>Groundnuts<br>* Grown with sorghum | Late-maturing sorghum<br>Sesame* (mixed/sole crop)<br>Cowpeas* (intercrop)<br>Cotton<br>*Grown with sorghum |
| AREA PLANTED | less than 1/4 ha | 1/4 to 1 ha | 2 to 8 ha |
| PATTERN OF CULTIVATION | More or less continuous cropping with manuring every year<br>Plot usually fenced | Long periods of continuous cropping made possible by manuring, Exhausted sites left fallow 5-15 years. Plots are usually fenced. | Bush-fallow system. Sesame or cotton first year, with 5-10 years of sorghum, followed by 6-20 years fallow |
| LAND PREPARATION | Weed-clearing with short and long handled hoes; some brush/grass burning and rock clearing/removal | Similar to house garden Crude terracing serves to clear the site of rocks, contain run-off and prevent manure and soil loss. | New land cleared with axes and hoes; old grass grass sometimes burned to kill newly germinating weeds; hoe cultivation also used |
| TIME OF PLANTING | Early to late June | Early to late June | Mid-June to late July |
| TIME OF WEEDING | Late June, Mid-July and Mid-August | Mid-July and Mid-August | Mid-July and Late August |
| TIME OF HARVESTING | Early-Mid September | Early to Mid-September | December-January |
| YIELDS (KG/HA) | 600-800 kg/ha (sorghum) | 300-500 kg/ha (sesame)<br>700-900 kg/ha (ground nut) | 700-1400 kg/ha (Sorghum) |
| DISPOSITION OF CROPS | Mainly for household consumption prior to main sorghum harvest | Cash and for current season consumption | Sorghum mainly for food, others for food and cash |
| SOURCE OF LABOR | Both sexes, but mainly women | Both adult men and women | Both sexes, mainly adults, dominated by men; reciprocal work parties common |

## Livestock Production and Patterns of Resource Utilization

Livestock production among the Nuba is based largely on a sedentary system of management dominated by cattle and goats, although sheep and pigs are also raised to varying degrees, according to location and the influence of Islam. Patterns of resource utilization are characterized by relatively unrestricted grazing and high mobility, frequently involving a seasonal caternary sequence of movement between hilltops in the rainy season and the cracking-clay plains during the dry season.

Because crop cultivation is primarily the responsibility of adults while herding is entrusted to young boys and teenagers, conflicts over the allocation of labor are minimal, particularly since animals of several households are generally herded together during movements to and from grazing and water. Cattle are usually separated from small ruminants because of differences in their feeding habits and water requirements. In the rainy season, cattle commonly spend two to three months in the hills where special bush-enclosed cattle camps are constructed to house both the herders and animals. This seasonal pattern of cattle movements was developed as a rational response to the high incidence of biting insects and mud associated with the cracking clays during the rains. Although hilltop grazing is by no means insect-free at this time of the year, the practice of building smoke fires in confined cattle enclosures, coupled with the less dense vegetation and greater wind velocity typical of higher elevations, contributes considerably in reducing insect problems. Moreover, the movement of animals away from heavily cultivated areas during the growing season provides added security against crop damage inflicted by tresspassing livestock. Sheep and goats at this time are grazed relatively close to the household on footslopes and hillsides, but extra care is devoted to keeping animals out of cultivated plots. Since small ruminants return to the household in the afternoon or evening, it is often necessary to erect thorn-bush fences (usually from the coppicing tree, Ziziphus spina-christi) around near farms and house gardens to avoid crop damage by animals.

At the start of the dry season, cattle are brought down from the hills to graze on the footslopes and lower hillsides, and to take advantage of crop residues following the harvest of early-maturing cereal crops. The use of crop residues, which are available to all classes of livestock, has the added benefit of concentrating manure in the harvested near farms and house gardens. In this regard, terracing with rock borders is used to increase water infiltration and to prevent run-off and loss of manure during the rains. The results allow a fairly long period of continuous cropping in these locations. As the dry season progresses, large and small ruminants graze more frequently in the clay plains, and are forced to travel longer distances for water and forage, but are kept well away from unharvested fields. Crop residues from the main sorghum and cowpea harvest in the far fields during December and January provide a valuable source of fodder for the mid-part of the dry season, but these are quickly used up by the livestock of migratory transhumants and other farmers. Limited quantities of supplementation are provided to livestock, primarily cattle, from groundnut tops, brewers residue from beer-making, and the remains of threshed sorghum grain. The two latter sources are low in quality but permit a rapid intake of necessary bulk with a low rate of energy expenditure. By the end of the dry season, grazing is confined almost exclusively to the cracking clays, and cattle frequently travel 20-25 km for water and grazing on a daily basis.

Sources of water for livestock vary according to location, and are generally widespread in and around the hills during the rainy season. However, most of these supplies are ephemeral in nature, with the result that water availability is extremely limited in the dry season, and confined largely to localized sites of shallow, hand-dug wells, although occasional government wateryards (boreholes) and hafirs (machine-excavated reservoirs in the clays) are also found in the region.

Herd sizes and compositions of cattle and goats in typical Nuba households owning livestock are presented in Table 13, along with important production variables. Cattle generally reflect low productivity with slow rates of growth and maturation, extended calving intervals, and relatively high mortality.

TABLE 13: COMPOSITION AND PRODUCTIVITY OF THE LIVESTOCK COMPONENT IN THE NUBA SEDENTARY SYSTEM

| HERD COMPOSITION[1] | CATTLE | HERD COMPOSITION[1] | GOATS |
|---|---|---|---|
| | % | | % |
| Calves <12 months | 19.5 | Kids <6 months | 38.0 |
| Females 12-24 months | 2.9 | Females 6-12 months | 11.6 |
| Males 12-24 months | 3.0 | Males 6-12 months | 4.1 |
| Females 2-4 years | 10.0 | Females 13-24 months | 30.6 |
| Males 2-4 years | 9.5 | Males 13-24 months | 2.5 |
| Females > 4 years | 45.1 | Females> 2 years | 13.2 |
| Bulls/Castrates 4 years | 10.0 | Males > 2 years | - |
| Number of Animals Sampled | 697 | Number of Animals Sampled | 121 |
| Number of Households | 36 | Number of Households | 6 |
| Mean Animals/Household | 19 | Mean Animals/Household | 20 |

PRODUCTION CHARACTERISTICS

| PRODUCTION VARIABLES | CATTLE | GOATS |
|---|---|---|
| Age at 1st Parturition | 4 - 5 years | 11 - 14 months |
| Parturition Interval | 23 months | 9 months |
| # Offspring/Life-time of Breeding Female | 3 - 5 | 4 - 7 |
| Calving Rate/Annum | 43.5 % | 173.6 % |
| % Breeding Females | 45.1 % | 55.4 % |
| % Breeding Males | 8.8 % | 6.6 % |
| Pre-weaning Mortality (estimated) | 10 % | 10 % |
| Adult Mortality (estimated) | 10 - 20 % | 10 - 15 % |
| Production Index[2] | 0.284 | 1.211 |

1 Herd compositions were calculated by examining all animals in household herds

2 Production indices = (12/parturition interval) X % Breeding Females in Herd X (1 - neonatal mortality) X # of offspring/parturition. For cattle, percent breeding females in herd excludes animals under two years; for goats it excludes animals under six months.

Goats by contrast show far superior performance with fairly high outputs of production and herd compositions containing a high proportion of breeding females.

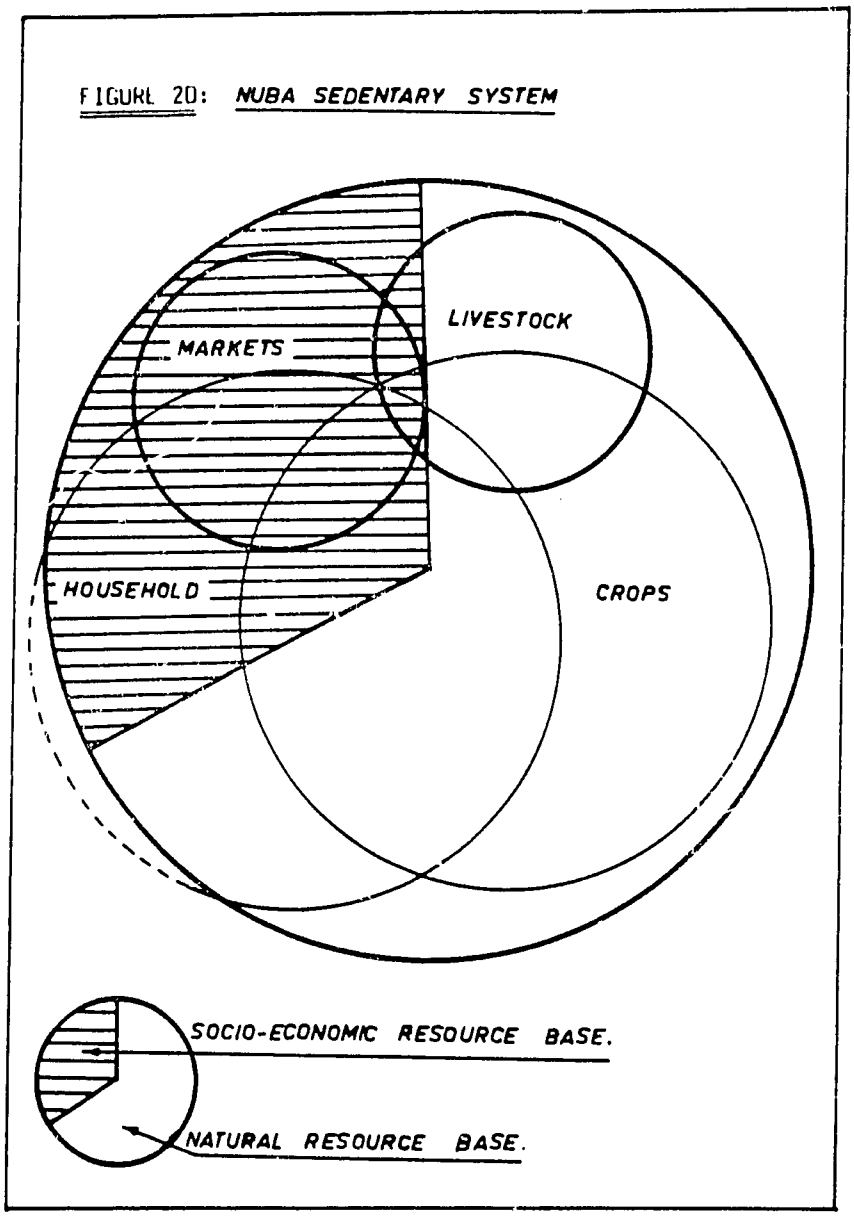
## Contraints to Production

Preliminary identification of constraints was based upon frequent interviews with producers coupled with empirical field observations for added credibility to answers given. The importance of developing close relationships with cooperating individuals was emphasized since discussions with new acquaintances often proved misleading. The constraints affecting the agronomic component are too numerous to discuss individually here, except to note the most important, (1) depletion of soil fertility due to excessive, continuous cropping and lack of adequate rotation systems, (2) debililtating effects of parasitic-weed infestations such as Striga, (3) late planting and weeding, which somestimes reflect shortages of labor, (4) low plant population densities, (5) birds and various insect pests which consume grain during planting and harvesting, and affect rates of germination and plant vigour, and (6) covered smut and other plant diseases.

Livestock constraints are almost invariably associated with poor nutrition during the dry season, inadequate water distribution, insect and parasitic pests, and outbreaks of contagious diseases such as pleuro-pneumonia and rinderpest. Causal factors associated with these conditions were addressed through appropriate diagnostic procedures in the formulation of research programs.

## Establishment of a Research Program

Although the Nuba sedentary system is dominated by crops, livestock play a crucial role in overall production and marketing. The interacting and dynamic nature of these various agricultural activities is graphically depicted in Figure 20.




1 Circle sizes represent the relative spheres of influence by component parts of the system. The distinction of households from agricultural activities represents decision-making, resource allocation, and various activities to fulfill other domestic needs (e.g., firewood, water, construction material, market goods). Circles falling partially outside the limits imposed by the natural resource base indicate improper or excessive land-use pressures. The natural environment ultimately determines how large a particular sphere becomes. Problems of low or declining agricultural productivity and resource deterioration can be reversed by decreasing the demands from specific components, improving management and resource utilization, and/or increasing the integration among interacting activities.

The development of research priorities for specific recommendation domains was done within the context of the ecological and land-use potential of the area to avoid implementing strategies which might lead to undesirable long-term consequences. The Nuba Mountain region enjoys the benefits of a productive resource base, and therefore, cultivation formed a dominant component in our research efforts. However, the capacity for crop production in the area represents only 40% of the land surface, indicating considerable scope for improving livestock production. Given the physical and biological nature of the region, improvements in the integration of livestock with current cultivation practices, offer high potential for increasing the productivity and stability of traditional households and the system as a whole. Much of the resulting impact will be felt through greater opportunities for investment, the purchase of crop and animal imputs, and the diversification of risk. For these and other reasons, livestock are considered important in the development of a research program for traditional sedentary producers in the Nuba Mountain area.

The basic factor determining the potential for any significant improvement in livestock production under this system of management is the forage resource base and its consequent impact on animal nutrition. Research therefore addressed important elements associated with the relationship between existing patterns of resource utilization and the current and potential productivity of the forage base. In terms of livestock production, the nutritional status of animals has major implications regarding key production variables such as growth rates, parturition intervals, milk yields, and mortality, as well as the susceptibility of animals to disease and their ability to withstand harsh environmental conditions. The dynamic nature of these interactions necessitated an approach that was comprehensive and holistic in context. Factors of particular importance involved an assessment of various land-use practices in terms of their efficiency and their impact on the natural resource base.

Initial diagnostic activities with livestock in the Nuba Mountain region focused on constraints relating to poor animal nutrition during the dry season. The purpose of these investigations was to isolate the principal causalities of specific constraints, and then to design appropriate interventions to reduce their detrimental effects. Problems posed by inadequate nutrition during the

dry season are basically a function of low forage quality and availability, which in turn are influenced by a number of inter-related factors. These are summarized as follows:

## Rangeland Deterioration

The deteriorated condition of rangelands in the Nuba Mountain area is characterized by reduced forage productivity, replacement of desirable plants by species of low palatability and nutritive value, and varying degrees of erosion. These factors collectively lower the carrying capacity of the region for livestock production. Range degradation is primarily the result of the frequent and widespread incidence of burning, which causes considerable loss of forage (thereby greatly affecting availability), as well as undesirable changes in the structure and composition of the vegetation. It also promotes erosion through increased run-off and dessication of the soil. Fires occur for a variety of reasons, the most important being due to antagonistic conficts and competing interests between the sedentary and migratory groups, and to carelessness on the part of honey gatherers and charcoal burners.

In contrast to rangelands farther north, grazing per se is not a major contributor to range deterioration because livestock pressures are not significant during the growing season when physiological damage to plants is most critical.

## Inefficient Resource Utilization

Existing patterns of grazing are inefficient in terms of available resources. Forage utilization in the dry season is such that as grazing progressively declines in both abundance and quality, animals are forced to travel greater distances for water and forage, and less time is spent grazing. The net effect is a negative energy balance, causing severe losses in weight and condition with obvious ramifications for maintenance, growth, and reproduction for the individual and the herd as a whole. Limited supplies of grazing in the dry season are exacerbated by the high incidence of burning, which as noted earlier, destroys large quantities of forage with little or no subsequent re-growth since range communities in the area are dominated almost exclusively by annuals.

A fundamental characteristic of current grazing practices in their exploitative nature and the absence of rational concepts of forage conservation, either in the form of established reserves for dry season grazing, or as harvested native hay for use during periods of critical food shortage. In addition, the prevailing system of bush-fallow cultivation on the cracking clays is poorly integrated with livestock production. The harvesting of late-maturing varieties of sorghum in the far fields, for example, is not accompanied by an efficient use of the abundant crop-residue for livestock feed. Part of the problem is that a field, once harvested, is open for use by the general public and their livestock, with the consequence that the crop producer has little opportunity to make use of the residues from his own field. Another part of the problem is the shortage of labor necessary to transport and store the crop residue for use later in the dry season, before it is consumed on-site by other herds of livestock.

The extensive system of fallowing in the cultivation cycle also has important implications regarding available land for grazing and the quality of forage from fallow areas. Under current practices, cracking clays are cultivated for a continuous period of 6-10 years, followed by a fallow period averaging 10-15 years with a range of 5-25 years. The result is that the amount of land in fallow is considerably larger than that under cultivation. This relationship is expressed by the following equation:

$$\text{Area in Fallow (km2)} = \frac{\text{Area under cultivation (km}^2\text{) X years in fallow}}{\text{Years consecutively cropped prior to fallow}}$$

Or, in ratio terms:

$$\text{\% of Fallow Land} = \frac{\text{Years under fallow}}{\text{Years in fallow \& cultivaton (cultivaton cycle)}}$$

Thus, for a system characterized by 8 years of continuous cropping with 12 years of fallow, the total area under cultivation is represented by 60% fallow land and 40% crops. The effect of this pattern has significant impacts on the

potential for grazing because of the unnecessarily large area in fallow, within which the development of desirable forage species is prevented or depressed by the disruptive influence of periodic cultivation (i.e., fallow vegetation is maintained at low seral stages of secondary succession). In summary, although fallow areas represent a large and potentially productive forage resource, under current practices, their grazing value is low.

### Water Availability

Water in the dry season is extremely limited in distribution. It is estimated that more than 30% of the rangeland areas in South Kordofan are unutilized by livestock due to the absence of dry-season sources of water. The scarcity of this essential resource leads to localized concentrations of livestock and intense competition for grazing around the few available supplies. The consequences, already elaborated on, cause a steady depletion of available forage in expanding arcs from the source of water. This forces an increasingly high rate of energy expenditure by livestock as the dry season progresses, coupled with a reduction in food intake due to the decreasing time available for grazing and the low quality forage. The result adversely impacts on the productivity of livestock.

## Forage Evaluation Trials[1]

### On-Station Trials

Several forage legume and grass evaluation trials were established on vertisols at the new Agronomy Research Station and at Telo during 1983. The overall objective of the trials was to evaluate several forage legumes and grasses, exotic as well as indigenous, alone and in combination, with regard to ease of establishment, weed competition, persistence, promiscuous nodulation (in the case of legumes), yield, and feed quality.

1. Forage Legume and Forage Legume/Grass Evaluation Trial

   Three trials were put out on the Agronomy Research Station, each under a different method of land preparation:

a) over 5 years fallow, native grass,

b) over 5 years fallow, native grass, sprayed with paraquat before seeding, and

c) fallow land of one season.

Legumes and grass/legume mixtures chosen were:

| | |
|---|---|
| Alysicarpus vaginalis | Desmodium/P. maximum |
| Centrosema pubescens | Sesbania/P. maximum |
| Clitoria ternatea | Siratro/P.maximum |
| Desmodium uncinatum | Stylo/P. maximum |
| Sesbania exaltata | Centro/Chloris gayana |
| Macroptilium atropurpureum (Siratro) | Clitoria/C. gayana |
| Leuceana leucocephala | Desmodium/C. gayana |
| Stylosanthes humilis (Cook Stylo) | Sesbaniaj/C. gayana |
| Vigna sp. (Kenya) | Siratro/C.gayana |
| Alysicarpus/Panicum maximum | Clitoria/Columbus grass |
| Centro/P. maximum | Cajanus/Columbus |
| Clitoria/P. maximum | Vigna (Kenya)/Columbus |

Each trial was a RCBD with 4 replications, each plot being 2 m x 8 m. With one exception, all plots were raked by hand with a locally purchased garden rake prior to broadcasting by hand, and were then raked again afterwards. The exception was for Leucana which was planted in hills made with a stick.

The paraquat was applied on July 5 and all three replica l's were planted on July 15, and the remaining 3 replicas on July 20.

Seeding rates, whether sown separately or in mixtures, for each 16 $m^2$ plot were:

| | |
|---|---|
| Panicum maximum | 10 gr |
| Chloris gayana (Elmba Rhodes) | 10 gr |
| Sorghum sp. (Columbus grass) | 15 gr |
| Centrosema pubescens | 15 gr |
| Desmodium uncinatum | 15 gr |
| Sesbania exaltata | 15 gr |
| Stylosanthes humilis | 15 gr |
| Cajanus cajan | 15 gr |
| Leuceana leucocephala | 16 gr |
| Macroptilium atropurpureum | 20 gr |
| Alysicarpus vaginalis | 25 gr |
| Clitoria ternatea | 25 gr |
| Vigna sp. (iron & clay mix) | 65 gr |
| Vigna sp. (from Kenya) | 65 gr |

Most of the imported seed arrived only a few days before planting so no germination tests could be made. We did not wish to use any type of mechanization which would not be available to traditional farmers but it seemed that the farmer could rake in the seeds in an attempt to cover them with soil. There were no rain gauges installed at the Agronomy Research Station in July, but records from the WSARP compound about three km away showed only 39.3 mm for July and 183 mm for August. The long time averages for these two months are 139 mm and 172 mm respectively.

In addition to the above, three perennial grasses and three legumes were broadcast by hand over larger plots on grass covered fallow. The three legumes and one legume/grass mixture were broadcast on 1/2 feddan plots and the three grasses broadcast on 1/4 feddan plots, the latter sprayed with paraquat the day before broadcasting the grass seed. The legumes were broadcast at the rate of 1 kg/plot on July 3 and the grasses at the rate of 200 gr/plot on July 5. Species evaluated were:

Chloris gayana (Boma Rhodes)
C. gayana (Elmba Rhodes)
Panicum coloratum
Stylosanthes humilis (Cook Stylo)
Macroptilium atropurpureum (Siratro)
Clitoria ternatea
Clitoria/Elmba Rhodes

Observations made throughout the season showed that none of the exotic legumes and none of the grasses had emerged. The only genera that appeared to be growing were Phaseblus, Lablab, Doliches, Vigna, Clitoria, and Cajanus. No attempt was made to control weeds as the traditional farmer would and could not take time to do so. However, it was several weeks before competition became severe on the trials seeded in native grass and from four to six weeks before any real competition became pronounced on other trials.

Tests made later in the laboratory showed that germination for many of the nonindigenous genera was poor.

2. Legume Evaluation Trial

This trial was conducted on cracking clay soil at Telo. The land was plowed and smoothed somewhat by dragging a large, heavy chain. Seeds were planted in small furrows spaced 60 cm apart. Row lengths were 5 m if seed supply was limited and 10 m or more if seed supply was plentiful. All plantings were made on July 6 & 7, 1983. A total of 73 different lines were planted without replication due to low quantities of seed of some species.

An evaluation was made on September 17 and the observations summarized in Table 14. The data show that only one genus (Macroptilium lathyroides and M. atropurpureum) not indigenous to Sudan emerged. All other general that grew were indigenous whether or not the seed used actually came from Sudan.

TABLE 14
Qualitative Evaluation of Non-Replicated Legume Screening Trials at the Telo Research Site, Kadugli - 1983 Season

| Species/Variety | Height and Productivity | Growth Stage | Root System | Nodulation |
|---|---|---|---|---|
| Clitoria ternatea* | 50-60 cm high; dense stand fairly leafy | Blooming with few green pods | Good-Excellent | Well nodulated with small active nodules |
| Alysicarpus vaginalis*** | No growth or germination | - | - | - |
| Sesbania exaltata*** | 60 cm high; sparse stand; rather stemmy | Not blooming | Fair | Nofulation absent |
| Phaseolus trilobus* (Phillipesara) | 70 cm high; extremely dense stand; very leafy | Not blooming | Excellent | Extremely well nodulated; large, very active nodules |
| Cajanus cajan* | 90-110 cm high; moderately dense stand; stemmy/woody | Not blooming | Good-Excellent | Extremely well nodulated; large, very active nodules |
| Lablab purpureus* | 70-80 cm high; good, dense stand; leafy | Not blooming | Excellent | Well nodulated; large, but non-active nodules |
| Vigna sp. (iron and clay mix)*** | 30-40 cm high; good, fairly dense stand; leafy | Pod stage, green and abundant | Fair | Fair nodulation; nodules small and very active |
| Canavalis ensiformis* | 30 cm high; sparse stand; poor-fair leafiness | Not blooming | Fair | Nodulation absent |
| Cajanus cajan** (7 lines) | 80-90 cm; sparse stands; stemmy | Not blooming | Fair | Nodulation poor or absent |

Table 14 (Continued):

| Species/Variety | Height and Productivity | Growth Stage | Root System | Nodulation |
|---|---|---|---|---|
| Dolichos lablab** (3 lines) | 30 cm high; fairly good spreading stand; small leaves | Not blooming | Good | Well nodulated; large, but non-active nodules |
| Lablab purpureus*** (rongai) | 70-90 cm high; good dense stand; leafy | Not blooming | Excellent | Very well nodulated; large, but non-active nodules |
| Vigna uniguiculata** (2 lines) | 30 cm high; low dense stand; leafy | One blooming One pod stage | Good | Well nodulated; medium sized, active nodules |
| Vigna uniguiculata** (PI337506, EA12575) | 50 cm high; good dense stand; leafy | Pod stage | Good | Well nodulated; medium very active modules |
| Vigna sinensis** EAI-1528 (Brahman Victor) | 50 cm high; good dense stand; leafy; some insect attack | Pod stage | Good | Very well nodulated; medlium sized very active nodules |
| Vigna sinensis** EAI-1525 (Arlington) | 40 cm high; good dense stand; leafy | Pod stage | Good | Moderate nodulation; moderately active nodules |
| Vigna sinensis** EAI-1524 (Jackson Alabama) | 40 cm high; fairly good stand; leafy | Pod stage | Good | Weakly nodulated; fairly active nodules |
| Vigna sinensis** EAI-1522 (Giant romston) | No growth or germination | - | - | - |
| Vigna sinensis** EAI-1523 (Groit) | 30-40 cm high; fair stand; leafy | Late bloom/ Early pod | Fair | Weakly nodulated; non-active nodules |
| Vigna sinensis** EAI-1526 (Brahman) | 40 cm high; good dense stand; leafy | Early bloom | Good | Moderate nodulation; moderately active nodules |

Table 14 (Continued):

| Species/Variety | Height and Productivity | Growth Stage | Root System | Nodulation |
|---|---|---|---|---|
| Vigna sinensis** EAI-1527 (Brahman) | 30 cm high; sparse stand; moderately leafy | Not blooming | Fair | Weakly nodulated; but with active nodules |
| Vigna sinensis** EAI-1529 (Victor) | 30-40 cm high; fair-medium stand; fairly leafy | Blooming | Good | Weakly nodulated; but with active nodules |
| Glycine wightii**EAI-2560 & 2561 (2 lines) | No growth or or germination | - | - | - |
| Glycine wightii** (3 lines) | No growth or germination | - | - | - |
| Leuceana leucocephala** (12 lines) | No growth or germination | - | - | - |
| Desmodium uncinatum*** | No growth or germination | - | - | - |
| Desmodium intortum*** | No growth or germination | - | - | - |
| Stylosanthes scabra*** (2 lines) | No growth or germination | - | - | - |
| Stylosanthes hamata*** (1 line) | No growth or germination | - | - | - |
| Stylosanthes humilis*** (4 lines) | No growth or germination | - | - | - |
| Stylosanthes guianensis*** (2 lines) | No growth or germination | - | - | - |
| Macroptilium lathyroides*** (phasey bean) | 60 cm high; very good stand; moderately leafy | Early pod | Good | Weakly nodulated; moderately active nodules |

Table 14 (Continued):

| Species/Variety | Height and Productivity | Growth Stage | Root System | Nodulation |
|---|---|---|---|---|
| Macroptilium atropupureum*** | 30 cm high; fair low stand; fairly leafy | Not blooming | Fair-Good | Moderate nodulation; fair to poorly active nodules |
| Macrotyloma uniflorum*** | No growth or germination | - | - | - |
| Macrotyloma axillaris*** | No growth or germination | - | - | - |
| Centrosema pubesens*** | No growth or germination | - | - | - |
| Lotononis bainesii*** | No growth or germination | - | - | - |
| Pueraria phaseoloides*** | No growth or germination | - | - | - |
| Trifolium alexandrium*** | No growth or germination | - | - | - |
| Vigna sp.*** (Red Laloona) | 30-40 cm high; sparse-fair stand; fairly leafy | Early pod | Fair | Well nodulated; good active nodules |
| Cajanus cajan*** | 90-110 cm high; good stand; stemmy | Not blooming | Good | Nodulation sbsent |
| Lablab purpureus*** (highworth) | 60-70 cm high; good dense stand; leafy | Not blooming | Good | Well nodulated, but with non-active nodules |
| Mucuna sp.*** CPI-11843 | No growth or germination | - | - | - |
| Alysicarpus monilifer*** | No growth or germination | - | - | - |
| Sharb El Shamseen | No growth or germination | - | - | - |

* Acquired locally
** Acquired from Kenya
*** Acquired from WSU (Australia and the U.S.)

None of the other exotic lines emerged, probably due to old, nonviable seed. The imported seed arrived only a few days before planting so there was not sufficient time to make any germination tests.

## 3. Grass Evaluation Trial

This non-replicated trial was carried out at Telo on cracking clay soil that had been plowed and smoothed with heavy chains. Plots of 2 m x 4 m were seeded at the rate of 30 gr/plot for all species with the exception of three Bothriocloa varieties which were seeded on 2 m x 2 m plots at the rate of 10 gr/plot. All seeds were hand broadcasted and raked in on July 12. The following species were seeded:

Panicum coloratum (purple pigeon grass)
P. maximum (common guinea)
P. maximum (Gatton)
P. maximum (Green)
P. maximum (Hamil)
P. maxiomum (Bambatsi)
Brachiaria obtusiflora (indigenousj)
B. decumbus
Bothriochloa insculptum (Bower)
B. insculptum (Emerald)
B. insculptum (Biloela)
B. pertusa
Chloris gayana (Elmba Rhodes)
Setaria sphacelata (Nandi)
S. sphacelata (Narok)
S. sphacelata (Kazungula)
Sehima ischaemoides (indigenous)
Melinis sp. (molasses grass)

The only species that emerged and grew were Sehima ischaemoides and Brachiaria obtusiflora. Both were the only indigenous species in the trial, and both exhibited good growth and seed production.

## On-Farm Trials

In addition to the on-station trials, Clitoria ternatea was broadcast by hand at the rate of 2 kg/feddan on two one-feddan plots in the Bilinya area and one in Hamra, all on vertisols, owned by local farmers.

Although a number of the Clitoria plants observed throughout the season were from roots of established plants, there were also a number of seedlings. It remains to be seen how much the Clitoria, or any other introduced legume, can be increased in the very tall, dense grass vegetation that dominates shortly after the rains begin.

A better strategy for successful legume establishment and growth would be to plant on cultivated land that is about to enter the fallow period. Weed problems on such land are much less severe and the tall grasses are present at very low densities. The reduced competition should be sufficient to permit good legume establishment in one season.

## Overall Conclusions

The results showed that many of the seeds failed to germinate and perhaps others may have germinated and then dried up. This could be especially true for those trials planted on the Agronomy Research Station on July 3, 5, 15, and 20. There were no rains until very light showers on July 22, 23, 24, 26, and 27. These rains were not adequate to wet the soil to any depth to sustain root growth but were sufficient to germinate the seeds. Probably this surface moisture was dissipated in an hour or two after the sun came out.

Nevertheless, all legume seed of nonindigenous genera from Australia and the U.S., with the exception of Macroptilium sp., failed to germinate at Telo. Indigenous genera did germinate which indicates that some of the problem was nonviable seed rather than soil moisture.

New legume seed supplies should be ordered in plenty of time for next season so that germination tests may be made. We should also learn which seeds should be scarified before sowing.

In the meantime, until something better is found, three indigenous forage type legumes - Vigna sp., Phaseolus trilobus, and Clitoria ternatea -should be considered for inclusion in the sedentary cropping systems in the Nuba Mountain Region primarily for livestock feed and as a soil improving crop. These three grew well, nodulated freely with active nodules, and will produce seed if planted sufficiently early. Cajanus cajan - pigeon pea -had good growth and large active nodules but appears too stemmy to make good feed. Dolichos and Lablab produce abundant forage and usually had large but inactive nodules. These two species also bloom and set seed well after the time for harvest and therefore could not supply seed sources for farmers.

With regard to future tests and screening, greatest priority should be given to legumes rather than grasses because (1) legumes are often dual purpose and provide better quality forage, (2) grasses are locally abundant in the region and any improvement in quality and persistence is not likely to be cost effective, and (3) farmers are less likely to attempt the use of grasses over legumes.

## Forage Conservation for Supplementing Cattle - A Farmer-Managed In-Herd Trial

A major constraint to livestock productivity in the Nuba Mountains is the low level of nutrition late in the dry season. Declining forage conditions at this time coincide with a period of increasing energy expenditures, reduced food

intake, and high environmental stress due to the onset of the hot season. The result significantly impacts on the condition and productivity of livestock and their susceptibility to disease and mortality.

In view of the productive nature of vegetation in the cracking clays where little grazing occurs during the time of peak forage abundance and quality, the conservation of hay offers potential for alleviating poor animal nutrition at the height of the dry season. An experiment was therefore designed involving the harvesting and feeding of native cut-hay to traditional sedentary and transhumant groups of cattle.

During late September and early October, native pastures dominated by the grass species, Rottboellia exaltata and Ischaemum afrum, were harvested by hand, dried in the field, and transported by vehicle for safe storage at the research station until the feeding experiment was scheduled to begin. From the period April 1 to June 1, 1983, the harvested forage was used in farmer-managed feeding experiments to compare changes in weight between supplemented and control groups of sedentary and transhumant cattle. In both cases, the supplemented and control groups were similar in age and physiological condition. Supplemented groups consisted of 6 animals in the sedentary system, and 20 in the transhumant system. Equal numbers of animals were used as controls for each system of management.

Recommendations were made to the cooperating producers to feed hay to the experimental groups at a daily rate of 2.5 kg per animal, in a manner which would replace the usual afternoon grazing period. The rationale behind this was to reduce the stress and additional energy demands on the animals from the long distances travelled in search of grazing in the afternoon. Results of these experiments are briefly outlined below.

## The Sedentary Group

Data in Table 15 and Figure 21 show the amount and pattern of weight loss for the supplemented and control groups. Supplemented animals lost 33% less weight than the control group which was significant at the 95% confidence level. Visually, the supplemented group was in much better condition than the control,

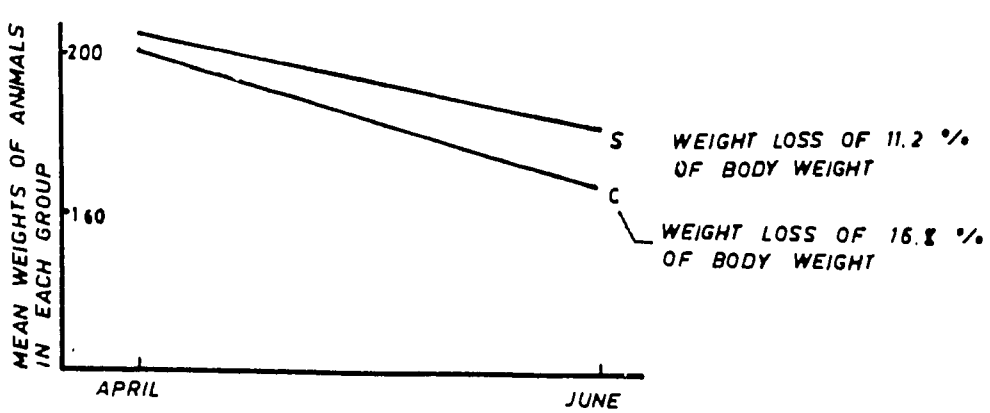
TABLE 15: Weight Changes in Control and Native-Hay Fed Groups of Cattle during the Late Dry Season (Non-Lactating and Non-Pregnant Females)

| | SUPPLEMENTED GROUP | | | CONTROL GROUP | | |
|---|---|---|---|---|---|---|
| ANIMAL NUMBER | STARTING WEIGHT kg | ENDING WEIGHT kg | PERCENT CHANGE | STARTING WEIGHT kg | ENDING WEIGHT kg | PERCENT CHANGE |
| 1 | 200 | 175 | 12.50 | 207 | 181 | 12.56 |
| 2 | 273 | 235 | 13.92 | 240 | 189 | 21.25 |
| 3 | 191 | 177 | 6.84 | 211 | 171 | 18.96 |
| 4 | 248 | 214 | 13.71 | 227 | 183 | 19.38 |
| 5 | 141 | 124 | 12.06 | 154 | 132 | 14.29 |
| 6 | 184 | 168 | 8.70 | 174 | 149 | 14.37 |
| TOTAL | 1237 | 1093 | - | 1213 | 1005 | - |
| MEAN* | 206 | 182 | 11.28* | 202 | 167 | 16.80* |

* Mean Weight Changes for Control and Supplemented Groups are significantly different at the 0.05 probability level

FIGURE 21: RESULTS OF SUPPLEMENTAL HAY FEEDING TO SEDENTARY NUBA CATTLE

CHANGES IN WEIGHT FOR SUPPLEMENTED & CONTROL ANIMAL GROUPS




S = HAY SUPPLEMENTED GROUP
C = CONTROL GROUP



F 05

and the owners were notably impressed by the results, claiming in follow-up discussions that conception rates among these animals were much improved over the usual pattern. These comparative improvements occured in spite of the fact that recommendations to replace the afternoon grazing period were not followed. It is anticipated that animals receiving a hay supplement will experience a substantially lower loss in weight with the elimination of the afternoon grazing period. It is also expected that improvements in the quality of hay produced, which was well below the potential last year, will occur with refinements in techniques. The effects should produce a considerable improvement over the results obtained during this past season.

## The Transhumant Group

The results of the feeding experiment with transhumant producers were far less satisfactory, primarily due to the influence of the human element in how the experiment was managed. In contrast to the sedentary producer, the hay provided to each transhumant was frequently fed to animals not part of the experiment, including donkeys and sick animals. While this reflected their perception of how best to feed the hay, the effect interfered with the design of the experiment to the point where variations in feeding could not be quantified. In addition, four animals died in the control group, and one in the supplemented group during the course of the experiment. A final problem occured with the attempt by some producers to exchange animals between the experimental groups and the rest of the herd, which was accompanied by claims that the exchanged animals were the same individuals present in the original groups.

Because of these problems, data gathered on this portion of the feeding experiment could not be analyzed. However, the fact that four times as many animals died in the control as the supplemented group could be attributed in part to the feeding of hay, although this could not be verified since the causes of death were unknown.

## Conclusions

Based on the results and observations made during the course of the experiment, the Nuba sedentary system appears better suited for the harvesting, storage, and feeding of native hay than the transhumant system. Apart from the greater willingness of sedentary farmers to cooperate and follow recommendations, several other characteristics make the system a more logical choice for implementing this type of intervention:

(1) Nuba farmers are accustomed to hard physical labor in many of their activities; hence they are more likely to accept the effort of harvesting and storing native forage

(2) The sedentary nature of the system permits better and more convenient control over the critical period of harvesting; the transhumants by constrast may still be engaged in seasonal migrations away from areas used for harvesting forage

(3) The herds of sedentary farmers are considerably smaller than transhumant herds, and therefore the quantities of hay needed are much lower

In the transfer of this technology, the feeding of relatively low-quality hay must be efficient in order to off-set costs of harvesting and storage, and to achieve significant improvements in the survival, health, and productivity of the animals involved.

## Feeding Crop Residues and Cut-Native Hay to Cattle During the Dry Season

In South Kordofan the dry season extends from November to June. During this period grazing deteriorates both in quantity and quality. Forage availability is particularly affected by outbreaks of fire and concentration of animals around permanent water sources. Many crops are grown in the province during the rainy season, the most important being sorghum, sesame, cotton and groundnuts

(GN). The residues of these crops are available for livestock during the dry season. In addition, the land is very productive in natural grazing, especially in the cracking clay and swamps (5000 to 8000 kg DM/ha). This resource is underutilized during the rainy season because most livestock are in North Kordofan. When animals are back in South Kordofan forage quality has already deteriorated, especially the crude protein content. Cutting forage while still green and storing it as hay for feeding during the dry season is thought to be one possible way of better utilizing this resource.

The study reported here compared groundnut hay/grazing, sorghum straw/grazing, cut native hay/grazing and grazing/no supplement. Each of the treatments was applied to bullocks in groups of ten animals of about two years of age, with supplemented groups fed at the rate of 2 kg of air-dried matter per day.

The crude protein (CP) content of the feeds is shown in Table 16. Groundnut hay had the highest CP content especially in the leaves. The stems contain less than half the amount found in the whole plant. Every effort should, therefore, be made to preserve the leaves during transport and storage of groundnut hay. The content of CP in sorghum straw and native hay is even less than that found in the diet selected by cattle grazing the same area during the late dry season (CP = 5.9%).

The dry matter intake of groundnut hay was significantly higher ($P<0.01$) than that of sorghum straw and native hay, the values being 1.9, 1.4, and 1.4 kg/d, respectively. The low intake of the latter supplements was a reflection of their low CP content, which was lower than what a grazing animal would select if given the option.

Figure 22 shows the growth of the animals during the period of supplementary feeding (28 February to 28 June 1983). Weights are presented as the change from the initial value. The group supplemented with groundnut hay was significantly heavier at the end of the dry season than those fed on sorghum straw, native hay, or unsupplemented. The latter three treatments were not significantly different ($P<0.05$).

Table 16: Crude Protein Content of Feeds (%)

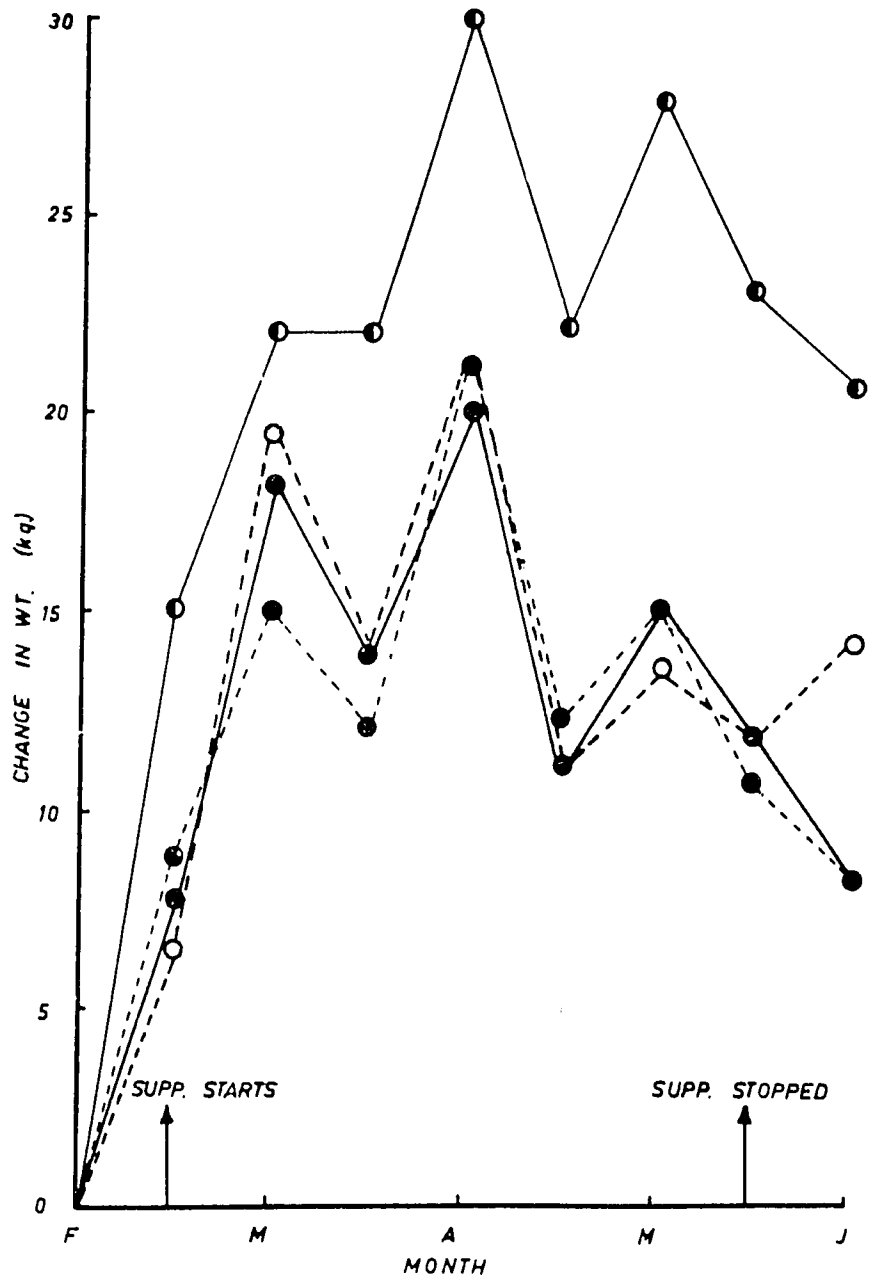
| Feed | (C.P) |
|---|---|
| GN Hay Whole Plant | 19.1 |
| GN Hay (Leaves) | 21.0 |
| GN Hay (Stems) | 8.9 |
| Sorghum Straw | 5.2 |
| Native Hay | 4.4 |
| Diet Selected by Grazing Cattle | 5.9 |

When allowed to migrate to North Kordofan and graze naturally during the rainy season, animals from all groups made substantial gains (see Fig. 23 and Table 17). The rate of gain was, however, not significantly different between treatment groups. It amounted to 0.534 kg/d with an average increase of 52.9% over late dry season weight.

It seems, therefore, that in a reserved area where an abundance of standing hay is available there may be no benefit from feeding low quality roughages such as sorghum straw or late cut native hay. In a natural situation, however, where grazing might have been destroyed by fire or by grazing pressure around permanent water sources, the feeding of crop residues may be invaluable in reducing weight loss during the dry season.

The superior performance of the group fed on groundnut hay emphasizes the need for a good protein source during the dry season. The finding that growth rates of the various groups of bullocks were not significantly different during the rainy season gives further credit to dry season feeding of good quality roughages, in that the higher weight at the end of the dry season is maintained during the rainy season growth period. As dura straw is available in large quantities, it is suggested that studies should be initiated with the aim of improving its nutritive value, by incorporating limited quantities of forage legume or oil seed cake in the supplementary ration.

FIGURE 22: CHANGE IN WEIGHT OF GRAZING BULLOCKS RECEIVING NO SUPPLEMENT (●) OR SUPPLEMENTED WITH EITHER GN HAY (◐), SORGHUM STRAW (○) OR NATIVE HAY (●).



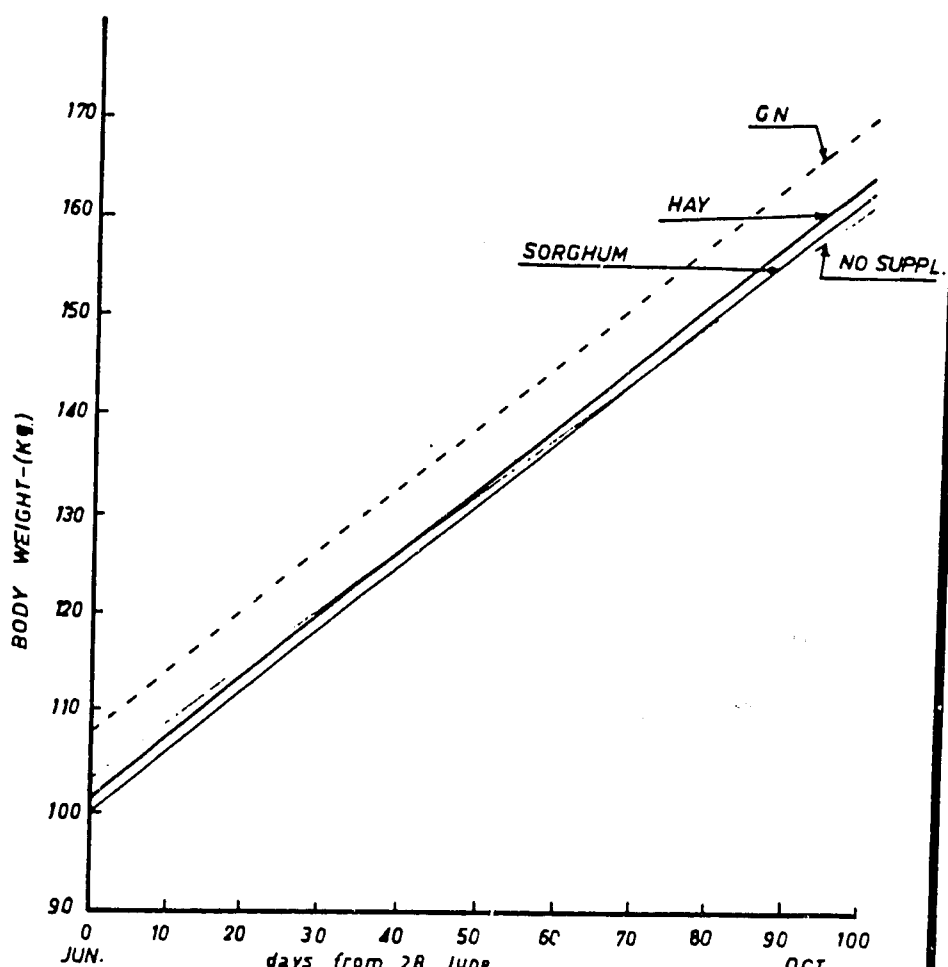



F 05

FIGURE 23: GROWTH OF BULLOCKS DURING RAINY SEASON

REGRESSION EQUATIONS

| | | | | | |
|---|---|---|---|---|---|
| GN | Y | = 106.06 | + 0.538 | x | ( r = 0.9986) |
| SORGHUM STRAW | Y | = 99.9 | + 0.540 | x | ( r = 0.9999) |
| NATIVE HAY | Y | = 101.2 | + 0.532 | x | ( r = 0.9969) |
| CONTROL | Y | = 101.5 | + 0.508 | x | ( r = 0.9968) |






F 05

TABLE 17: GAIN IN WEIGHT DURING RAINY SEASON (PERIOD 28 JUNE TO 8 OCT. 1983)

| PREVIOUS FEED | TOTAL GAIN ± SD (Kg) | GAIN/d ± SD (Kg) | % GAIN ± SD | MEAN WT. | N |
|---|---|---|---|---|---|
| GN HAY | 54.3 ± 9.73 | 0.531 ± 0.095 | 50.6 ± 6.78 | 107.5 | 10 |
| SORGHUM STRAW | 55.3 ± 10.83 | 0.540 ± 0.107 | 55.3 ± 10.16 | 100.00 | 7 |
| NATIVE HAY | 53.5 ± 7.23 | 0.526 ± 0.070 | 54.2 ± 8.64 | 100.0 | 6 |
| NO SUPPLEMENT | 51.4 ± 6.57 | 0.540 ± 0.107 | 51.6 ± 9.01 | 100.2 | 4 |

## Introduction of Animal Draft

The shortage of labor acts as a severe constraint to the efficiency and types of agricultural activities that are, or could be, conducted among sedentary producers in the Nuba Mountain Region. Animal draft offers high potential for substantially reducing labor costs for various production activities and allowing for an improvement in the efficiency and diversification of household enterprises.

Last year, two pairs of oxen, with carts, were used in researcher-managed on-farm trials with nearby sedentary producers as a means for improving the transport of a variety of agricultural products and other household needs. These

included harvested grain, cut native hay, crop residues, and thatching materials. To date, approximately 45 households have been directly involved in the use of animal draft, and considerable interest is being generated among other producers to acquire their own trained oxen and carts (see Table 18).

The primary advantage of this technology is the great savings in time and effort for transporting crops and forages from field sites, many as far away as 8 kms., to the household for storage. This savings in time should allow farmers to engage in other productive activities, which this year resulted in the transport of greater quantities of crop residues for livestock feeds during the dry-season and of building materials for extensive repairs on houses and in the construction of new structures. With regard to building, many farmers indicated that they would have delayed or reduced the quality or quantity of repairs on their homes until the following season if they had not had the use of animal draft.

Because of demonstrated success of this technology and its receptiveness among producers, the program for introducing animal draft will be expanded and improved upon for the 1984/85 season.

## VII. NOMADIC PRODUCTION SYSTEMS

### Introduction

The information presented in this section was obtained from secondary sources and from a preliminary reconnaissance survey undertaken during the months of February and March, 1983 in the southwestern region of Dar Kababish, North Kordofan. Dar Kababish was selected because it represents one of the most important camel and sheep production areas of the Sudan. Initial survey activities focused on those pastorialists whose primary production enterprise was camel-rearing. Camels represent an important means of subsistence for a large number of traditional households in North Kordofan, and the frequency of camel intrusion into dry-season grazing areas in South Kordofan has dramatically increased during the past two years, creating increased pressures on the limited dry-season natural resources, for both pastoral as well as sedentary producers in South Kordofan. The objectives of this survey were to; (1) identify the

TABLE 18: USES OF OX-DRAWN CARTS AND COMPARISON WITH TRADITIONAL HUMAN LABOR IN TWO NUBA VILLAGES

| Village Name | Number or Farmers | Product Transported | Number of Cart-loads | Weight/ Cart-load (kg) | Travel Time Cart-load (Hrs) | Weight/ Hand-Carried Load (Kg) | Walking Time/ Hand-Carried Load (Hrs) |
|---|---|---|---|---|---|---|---|
| Bilinya | 2 | Harvested Native Hay | 12 | 375 | 0.7 | 15-20 | 1.0 |
| | 8 | Sorghum Grain Heads | 5 | 500 | 1.2 | 15-20 | 1.8 |
| | 2 | Sorghum Stalks | 10 | 400 | 1.2 | 15-20 | 1.8 |
| Sema | 5 | Sorghum Stalks | 5 | 400 | 1.5 | 15-20 | 2.2 |
| | 28 | Grass Thatching | 34 | 350 | 1.7 | 15-20 | 2.3 |

1 The amount of grain and stalks transported by farmers was low because the sorghum had already been harvested by most farmers, and the stalks used by livestock at the time this trial began. Consequently, priority was transferred from grain and stalks to grass-thatching for repairing or constructing new roofs.

components of traditional camel (nomadic) production systems and assess their qualitative characteristics; (2) generate initial baseline data on production parameters and constraints; and (3) assess, in a qualitative fashion, management/husbandry practices and patterns of resource utilization.

## System(s) Characteristics

A spectrum of production systems were encountered during the course of this survey, from strictly sedentary, agronomic systems to migratory, livestock systems without any agronomic component. However, the majority of camel producers who were interviewed undertook a variety of production activities

including horticultural, field cropping, and camel, sheep and goat production. In all these cases, the production system was dominated by livestock, specifically camels.

The principal components of this system are indicated in Figure 24. Characteristically, this system included household, cropping, livestock, and market components, all set within an environment dominated by the natural resource base which exercised the principal limitation on both viable agronomic as well as livestock management strategies. Functionally, households undertook both agronomic and livestock activities, although cropping tended to be very opportunistic in nature and assumed much less importance than did livestock production, both in terms of social prestige and in quantitative contribution to household subsistence. Cropping and horticultural activities were characterized by low yields, generally the result of poor and unreliable rainfall, inability to build secure enclosures, insect pests and disease. Livestock productivity was understandably low, given the limitations posed by the natural resource base and the inability of producers to control livestock diseases. The socio-economic resource base was poorly developed, offering very limited household access to both commercial markets and social services.

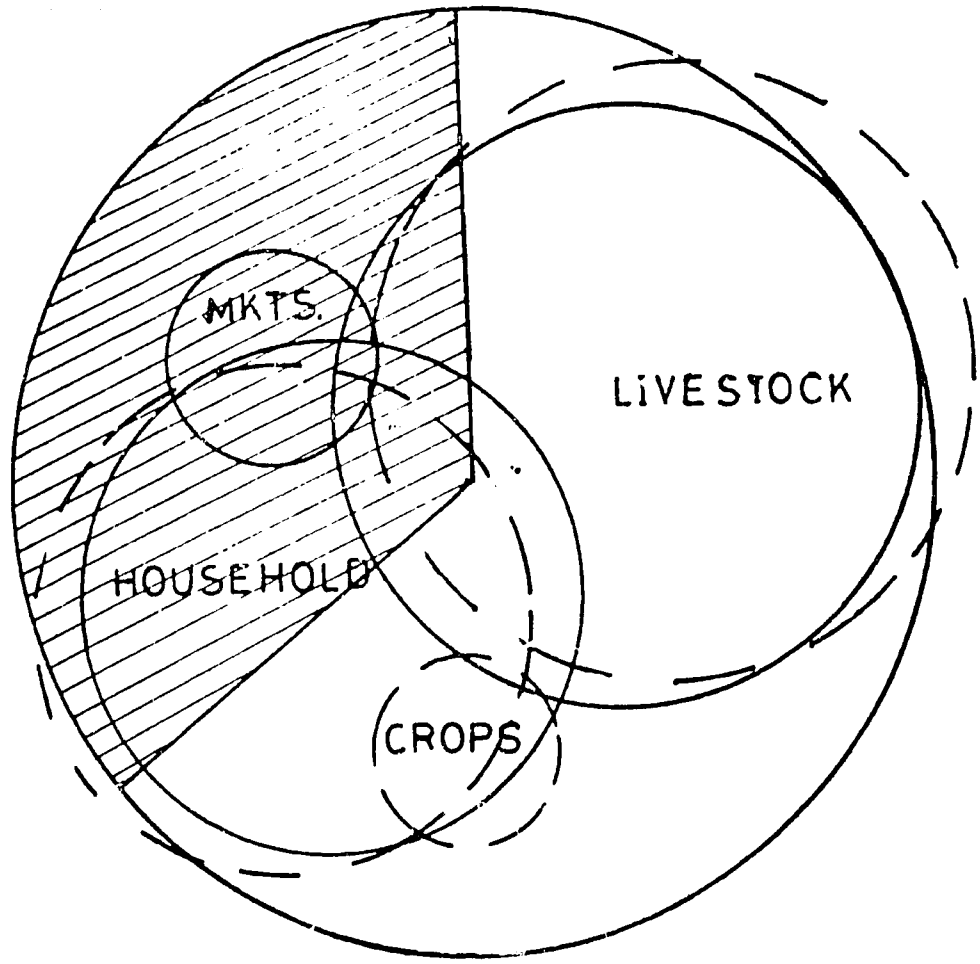
## Natural Resource Base

Dar Kababish is an area of approximately 32,000 sq. km located in North Kordofan between latitudes 14° N and 16° N. It is characterized ecologically as arid bush and grasslands to semi-desert with an annual rainfall of 150-250 mm and an evapotranspiration of 1600 to 1800 mm annually. Sandy soils, interspersed with loamy sandy and clayey areas predominate in the region, with frequent areas revealed a rocky subsurface where all topsoil had been eroded by wind. The vegetation is dominated by annual grasses and thorn scrub, predominately *A. millifera*. Acacias dominated the woody vegetation, particularly *A. nilotica* in alluvial drainage lines and depressions and *A. senegal*.

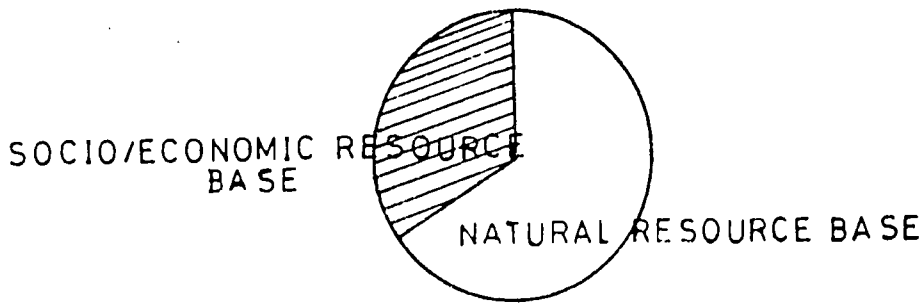
## Socio-Economic Resource Base

According to the 1973 census, the population of Dar Kababish was approximately 200,000 and increasing at an annual rate of 2.5%. The predominant ethnic group

FIGURE 24:




PASTORAL
PRODUCTION SYSTEM



is Arab, with Westerners and Nuba comprising about 15% of the total (Khogali, 1981). Household classification data for the period of 1956-1973 indicated a tendancy for sedentarization, with the percentage of nomadic households decreasing from a total of approximately 80% of the households to 69%, while the percentage of sedentary households increased from 17% to 30% (Khogali, 1981). Save for several widely separated urban areas, communications are virtually non-existent while social services, such as schools, medical facilities, and veterinary services are generally unavailable to rural households.

Cropping Component .

Agronomic practices generally follow a 4-5 year pattern of shifting cultivation. In most of the areas visited, rainfall during the past three years (1980, '81, '82) was estimated at less than 200 mm (Umm Badr recorded only one significant shower in 1982 while Sodiri recorded less than 130 mm of rainfall in 1982), making poor and unreliable rainfall the most significant constraint to cultivation in the survey area. Details of cultural practices, yields, and other production constraints are outlined in Table 19.

Although producers considered cropping a risky activity, the chance of an occasional average yield encouraged continuous cropping efforts. Interviews with several households indicated that for an average family of two adults and five children, average crop yields could supply food grain requirements for one year (although it should be noted that an "average" yield had not been experienced since 1977). Food grain needs were estimated as requiring the sale of 1 to 2 camels per year ($175.00 to $350.00, at 1983 prices), with total family needs requiring the sale of 3 to 5 camels ($525.00 to $875.00). Under these conditions, cropping could produce up to 50% of the household's subsistence requirements. Since labor was readily available for land preparation, planting and harvesting and alternative employment was scarce, opportunity costs for cultivation were relatively low. An additional incentive for cropping was related to the seasonal disproportionality between the purchase price of cereal grains and the selling price of livestock. Pastoralists frequently supplemented their sick and/or pregnant animals' diets with sorghum or millet during the dry-season, a period when household grain stores were low. During this period, the price of

TABLE 19

Pastoral Farming System in sandy soils in West/Northwest of El Obeid. Sample location; El Mazrub, Tinna, EL Merikh, Umm Kiriwa Abu Zaima. Sample Tribes; Kababish, Kawahla, Maganeen, Bani Jarar.

| Crop | Area* Planted fd | Seed Rate kg/fd | Cultivation time | Harvest Time | Yields kg/fd | Pests/ Disease |
|---|---|---|---|---|---|---|
| Millet | 12-15 | 3.5-4.5 | Before rains June/July | October 75-80 days | 200-650 | locust birds termites rodents |
| Sesame | 2-3 | 6.0-9.0 | After rains | September October | 95-190 | same as above |
| Sorghum (rarely) | 3-4 | 3.0-7.0 | After rains | October November | 160-245 | same as above |

* - per household with one adult male

grains generally increased while the sale price of livestock generally decreased. Sucn a cropping strategy has frequently been recorded for pastoralists, with Jahnke (1982) noting similar practices for pastoral groups inhabiting ecological areas with a unimodal pattern of rainfall as low as 200 mm annually.

Livestock Component

The major species of livestock produced in the survey area were camels, sheep, and goats, with individual producers generally rearing a mix of species. Goats were generally herded in flocks of 25-50 and kept most of the year in the vicinity of the permanent fariq to provide a source of milk when camels were not

available. Sheep as a rule were maintained in flocks, separate from camel herds, following a seasonal pattern of migration more or less restricted to Northern Kordofan. Camels, on the other hand, followed rather extensive migratory patterns, ranging from wet-season grazing areas in North Kordofan to dry-season grazing areas in the South. During this survey, emphasis was placed on characteristics of camel production and management.

Approximately 30% of Africa's camel population is resident in the Sudan (estimated at 3 million), and 40% of Sudan's national herd is resident in North Kordofan. Economically, the camel is an important export commodity in the Sudan, generating over 50% of the total revenue generated from livestock exports during the period of 1971 to 1977. In addition, camels also provide a source of meat for domestic consumption with over 15,000 heat being slaughtered during the same period. Camels also provide an important source of transport, and, within the traditional setting, are important sources of milk, wool, and hair.

The largest concentration of camels in North Kordofan is found in Dar Kababish. In this area, camels have traditionally utilized wet-season grazing areas in the north-northwestern part of the Dar, moving south to dry-season grazing areas between Umm Badr and En Nahud. Recently, however, due to low rainfall and poor grazing, this traditional migratory pattern has been pushed further south, at both its northern and southern extents.

Due to topographical and climatological factors, camel husbandry in North Kordofan can be classified as nomadic, with animals continuously moving in search of forage and water (Khogali, 1981). Camel herds are generally managed as separate breeding and working herds. Because intact, male camels become very aggressive during the rutting season, breeding herds usually contain only one breeding male at a time, generally in a ratio of 1 male to 30-40 females. Working herds and animals destined for sale are generally maintained and managed as male-only herds in numbers of 30-50 head. For working camels, castration is done between the ages of 5-6 years of age, and heavy work is generally postponed until the animal is 6-7 years old. The average working life-span of a camel ranges from 6-16 years.

Female camels generally have their first calf at 4-5 years of age, weaning their calf at approximately 12 months. Following weaning, females come into estrus and calve again in about 12 months, resulting in a calving interval of 2 years. On average, breeding females will produce 6-8 calves during their lifetime. Production characteristics for camels in the survey area are listed in Table 24.

Being herbivorous, camels obtain their food by browsing trees and shrubs, and by grazing. Under natural conditions, camels will eat a wide variety of plant types, although very little information is available on camel feeding habits under natural conditions. Supplementation with salt[1] is common throughout the year, being given every 14-21 days during the rainy-season and every 7-10 days during the dry-season.[1] Watering of camels depends on the breed and the amount of work being done and the season of the year. Breeding herds are generally watered every 10-20 days, with weekly waterings not uncommon during the dry-season when succulent browse/forage is scarce. Depending on the frequency of watering and work performed, camels drink between 8-20 gallons of water during a single watering, tolerating water losses up to 30% of their body weight if watering periods are extended to 30-40 days. A basic criterion which determines the size of camel herds and number of required herders is the amount of work required for watering.

Under the management conditions which exist in Northern Kordofan, both camels and sheep are exposed to a variety of diseases. The most important disease problems in sheep were identified as pneumonias, especially in lambs, sheep pox, enteritis, and internal parasites, the latter especially important in breeding ewes. In camels the most important disease problems appeared to be, in order of importance; mange, trypanosomiasis, internal parasites, and calf diarrhea. Anthrax, rabies, tetanus, and camel pox were occasionally cited as problems. In addition, brucellosis and tuberculosis may be public health problems because of the tendency to consume fresh, unboiled camel's milk.

---

1 Atron/dhereri, locally produced and containing predominantly $Ca(CO_3)_2$ and milich (NaCl)

Table 20: Production Characteristics of Livestock in a Nomadic Pastoral

| Species | Age 1st Parturition (year) | Parturition Interval (months) | # Offspring Lifetime | Milk Production (pounds) | Mortality Adult/Young (%) |
|---|---|---|---|---|---|
| Camels | 4-5 | 24 | 5-8 | 2-4/2 teats | less 5/30-50 |
| Sheep | 2 | 12 | 3-6 | 1/1 teat 6-8 months | 20-30/30-40 |

Note - Very few cattle were noted during the survey. Producers cited frequent watering and disease problems (Rinderpest) as the principal reasons.

Market Component

Preliminary market analysis focused on camel marketing procedures. The marketing of camels was usually done by specialized merchants, often involving the producers themselves without the participation of middlemen. The majority of camels marketed during the survey inquiry involved transactions between producers for immature male animals. Secondary information and interviews indicated that the majority of camels marketed in the survey area were destined for export to Egypt, a trading agreement which apparently was initiated in Kassala Region and later spread to other areas. Animals sold for export were generally male castrates, 5-7 years of age, at a price of between 350 and 400 Sudanese pounds ($290-$330) per head.[1] Preliminary discussions with several camel merchants in El Obeid indicated that camel export from North Kordofan were between 20,000 and 25,000 head in 1982. Under this export agreement, each exporter must sell 25% of his quota to the Egyptian government at a fixed rate, while the remainder can be sold on the open market. Camel trading with Libya is not officially sanctioned by the Ministry of Commerce. Assuming that 70% of the camel sales in the survey area are for export to Egypt and that approximately

1 Camel trade with Egypt is administered by the Ministry of Commerce through local councils which issue export permits to individual merchant-producers; thus, export figures were not available from the Livestock Meat Marketing Corporation.

40% of Sudan's national herd are resident in North Kordofan, annual offtake approximates 3%. Official offtake figures range from 3% to 4% annually (IBRD Livestock Marketing Appraisal Report, 1978).

Constraints to Production

Under present conditions, poor rainfall was the most important factor limiting cropping activities in the area. In addition, producers cited the need for improved methods of water harvesting which could be utilized on a location-specific basis where alluvial fans and khors receive considerable run-off during the rainy-season. Plant pests and disease were also cited as problems, specifically locust, weaver birds, termites, and rodents, and the need was also expressed for improved varieties of seeds and seed dressings.

The primary constraint limiting livestock production, cited by producers, was the unavailability of animal medications and vaccines. While unquestionably a significant constraint, deterioration of rangelands and consequent poor nutrition appeared to be the most significant constraint limiting productivity, especially for sheep which were more restricted in access to alternative grazing areas than were camels. Related to the poor availability of forage was the question of water availability, although the timing of this survey was not appropriate to adequately assess forage/water relationships. Disease control was a problem in the survey area, and according to producers, was a primary reason why cattle numbers, for example, had decreased sharply during the past several years, the result of recent Rinderpest outbreaks.

## FUTURE ACTIVITIES

Virtually all interventions suggested by producers for improving agronomic and livestock production in this area could well result in greater pressures on an already fragile ecosystem, and should be implemented where salvage of the natural resource base appears possible. In many areas cropping is only feasible if efforts are made to utilize the lee-side of jebel footslopes, natural khors and alluvial fans. Improved water catchment, terrace cultivation, and water spreading techniques should be developed to maximize the use of valuable surface

run-off. In those villages where horticultural activities have potential, efforts should be made to provide producers with extension assistance and inputs in the form of improved seeds, insecticides, and improved cultural techniques.

For the livestock component, substantial improvements in both camel and sheep production appear feasible. Such improvements will likely lead to an initial increase in animal numbers and possible increased grazing pressures. Diagnostic studies should be implemented to identify and evaluate resource utilization patterns of predominant livestock species in the area to provide an assessment of what level of livestock productivity could likely be supported on a long-term basis in the area. Such studies would evaluate current range/forage conditions in terms of available plant cover and composition, foraging patterns and food preferences, diet quality and composition, total voluntary intake, and management/husbandry practices. Socio-economic data relating to decision-making and resource utilization by households would be interrelated with livestock production data in an attempt to quantify pastoral system productivity. An assessment should be made of the potential improvements in productivity which may be possible through adoption of inteventions designed to more efficiently utilize the natural resource base and maintain its long-term productivity.

## VIII. ADDITIONAL ACTIVITIES CONDUCTED IN 1983

### Meetings, Conferences, and Workshops

March, 1983 — Western Sudan Agricultural Research Project Farming Systems Workshop, Bunderson, Fadlalla, and Cook. Papers presented: "Natural and Domesticated Resources in Kordofan in Relation to Farming Systems Research" - Bunderson; "The Role of Farming System's Policy in Farming Systems Research" -Cook.

April, 1983 — Western Sudan Agricultural Research Project Regional Planning Workshops, Bunderson, Fadlalla, and Cook. Papers presented: "Relationships between WSARP Research Programs and Rangeland Utilization in Western Sudan" -Bunderson;

"Nomadic Production Systems in Norther Kordofan - A Reconnaissance Survey" - Cook; "Transhumant Production Systems in South Kordofan" - Fadlalla.

| | |
|---|---|
| May, 1983 | Planning Workshop on the Ghazala Gawazat Research Station -Past, Present, and Future Research Activities, Khartoum, Bunderson, Fadlalla, and Cook. |
| July, 1983 | Research meetings and collaboration with Dr. J. Holechek, Range and Animal Science Department, New Mexico State University. Field activities were conducted at San Angelo State University, and Texas A&M Research Station and Ulvalde Research Station. - Fadlalla. |
| July, 1983 | Annual Meeting of the American Society of Animal Science, Washington State University, Pullman, Washington, U.S. -Fadlalla. |
| July, 1983 | Research collaboration, Department of Range and Forestry, Washington State University, Dr. Jack Nelson - Fadlalla. |
| August, 1983 | Visited the Rowett Research Institute, Aberdeen, Scotland. - Fadlalla. |
| September - October, 1983 | Attended a course in Animal Nutrition and Forage Legume Evaluation Techniques, Internal Livestock Center 1983 Africa, Addis Ababa, Ethiopia. - Fadlalla. |

## Consultancies and Linkages with Other Projects

| | |
|---|---|
| May, 1983 | Conducted a field trip to South Darfur to examine areas for potential cooperation between Western Savannah Development Corporation and WSARP -Bunderson, Fadlalla, and Cook, trip report available. |

October, 1983 Completed a short-term consultancy for Western Savannah Development Corporation on appropriate techniques and procedures for evaluating and monitoring range conditions and carrying capacities in South Darfur. -Bunderson, report available.

## Publications

a. External to the Project

(1) Pastoral Systems in Arid and Semi-Arid Africa: Basic Problems in Resource Management (November 1983 -Bunderson, Cook, Fadlalla, for the 2nd Int. Rangelands Congress).

(2) The Nature and Influence of Fire on the Range Ecology of Semi-Arid Savannas in Western Sudan (November 1983 - Bunderson, for the 2nd Int. Rangelands Congress).

(3) Farming Systems Research and Development for Extensive Livestock Systems in Arid and Semi-Arid Africa. (August and September, 1983 - Cook, Bunderson, Fadlalla, and Henson, for Kansas State University Workshop, October, 1983).

(4) The Design of Farming Systems Research for Pastoral Systems in Africa (January-March, 1984 - Cook, Bunderson, and Fadlalla, for Agricultural Systems Journal).

b. Project Research Reports

(1) Livestock Production Systems - The Case of Western Sudan, Bunderson et al., Research Report #1.

(2) Dar Kababish - Exploratory Production Systems Survey, Cook, Research Report #2.

(3) Transhumant Production Systems. The Nutritional Status of Transhumant Cattle During the Dry-Season - A First Approximation, Cook et al., Research Report #4.

(4) Transhumant/Nomadic Production System(s). The Nutritional Status of Sudan Desert Sheep - A First Approximation, Cook, Research Report #3.

## IX. REFERENCES


Ballarini, G. and E. Corbella, 1972. Plasma proteins in some disease states of calves. Folia Veterinaria Latina, vol. 2, no. 4.

Booker Agriculture Internation Limited and the Center for Tropical Veterinary Medicine, Edinburgh, 1981. Regional Animal Disease Control Project, vol. IV - Sudan.

Boudergues, R. and H. Calvet, 1972. Serum protein of Gobra zebus in Senegal: quantitative seasonal variations. Veterinary Bulletin, 42: 565.

Bremen, H. and C.T. de Wit, 1983. Rangeland productivity in the Sahel. Science, 221, 4618: 1341.

Brown, L.H., 1963. An assessment of some development schemes in the light of human needs and the environment. Proc. of the 9th Technical Meeting IVCN. Nairobi.

Bunderson, W.T., 1981. Annual Report, Range Research Activities. Western Sudan Agricultural Research Project No. 8.

_____, 1984 (a). The nature and influence of fire on the range ecology of semi-arid savannas in Western Sudan. Proc. of 2nd International Rangeland Congress, Adeliade, Australia.

_____, 1984 (b). Primary productivity and energetic relationships of wild and domestic ungulate communities. Proc. 2nd International Rangeland Congress, Adelaide, Australia.

Food and Agricultural Organization, 1980. Provisional Map of Present Degradation Rate and Present State of the Soil, Northeast Africa and the Middle East. FAO, Rome with UNEP and UNESCO.

French, M.H., 1957. Nutritional value of tropical grasses and fodders. Herb. Astr., 27: 1.

Gingrich, J.R., 1984. Agronomy Annual Report for 1984. Western Sudan Agricultural Research Project, Report No. 24.

Hoogstraal, H., 1956. Ticks of the Sudan. Research Report NM 005 050.29.07. U.S. Naval Medical Unit, Cairo, Egypt.

Hunting Technical Services, Ltd., 1981 (a). South Kordofan Central Districts Rural Development Plan, Borehamwood, U.K.

_____, 1981 (b). South Kordofan Rural Planning Unit. Annex No. 7 - Land Use and Planning Regions, Borehamwood, U.K.

International Bank for Reconstruction and Development, 1978. Livestock Marketing Appraisal Report, Sudan.

Jahnke, H.E., 1982. Livestock Production Systems and Livestock Development in Tropical Africa. Kieler Wissenschaftsverlag Vauk, International Livestock Center for Africda, Addis Ababa, Ethiopia.

Khogali, M.M., 1980. Sedentarization of Nomadic Tribes in the North and Central Sudan, a dissertation submitted for Ph.D. degree, University of Khartoum.

Kumar, S., U.R. Mehria, and U.B. Singh, 1978. Effect of dietary protein on plasma protein, plasma fractions, and plasma urea in ruminants. Indian J. of Animal Science, 50 (2): 146.

Livestock Meat Marketing Corporation, Sudan, 1981. Annual Report.

_____, 1983. Personal communication.

Pratt, D.J., and P.J. Greenway and M.D. Gwynne, 1966. A classification of East African rangeland with an appendix on terminology.; J. Appl. Ecol. 3: 369.

Resource Management and Research, Ltd., 1975. Sudan National Livestock Census and Resource Inventory. Sudan Veterinary Research Administration, Ministry of Agriculture, Food and Natural Resources, Khartoum.

Schalm, O.W., N.C. Jain and E.J. Carroll, 1975. Veterinary Hematology (3rd edition). Lea and Febiger, Philadelphia, Pennsylvania.

Shaner, W.W., P.F. Philipp, and W.R. Schel, 1982. Farming Systems Research and Development: Guidelines for Developing Countries. Westview Press, Boulder, Colorado.

Skerman, P.J., 1966. Land and Water Use Survey in Kordofan Province of the Republic of the Sudan. Doxiadis Associates, Athens.

Teitelbaum, J.M., N.A. Patrick, 1983. Socio-Economic Annual Report, Western Sudan Agricultural Research Project, Agricultural Research Corporation, Sudan.

Tobel, H., 1978. Pathogenicity of Trypanosomes; Serum Protein Changes in Bovine Trypanosomiasis: A Review. IDRC Workshop on the Pathogenicity of Trypanosomes, Nairobi, Kenya.

Wilson, R.T., and S.E. Clarke, 1976. Studies on livestock of Southern Darfur, Sudan. II. Production traits in cattle, Trop. An. Hlth. Prod. 8: 47.

Winrock International, 1981. Livestock Program Priorities and Strategy. U.S. Agency for International Development, Morrilton, AK.

Woodhead, T.W., 1979. Studies of Potential Evapotranspiration in Kenya. Water Development Department, Nairobi, Kenya.

Yakoob, A.Y. and P.H. Holmes, J.J. Parkins, and J. Armour, 1983. Plasma protein loss associated with gastrointestinal parasitism in grazing sheep. Res. in Vet. Sci., 34: 58.

# X. APPENDIX

Tables 1-15: Vegetation Cover and Composition from Exclosures and Transect Lines in the Nuba Mountain Region

Table 1: Structure and Composition Changes in Exclosure Vegetation, Nuba Mountains, South Kordofan

Exclosure No.: 1 Methods: Two-point frame on two transects 40m long each.

Soil Type: Gravelly grey sandy clays on dissected footslopes Vegetation: Hyparrhenia confinis-Combretum-Acacia gerrardii-Boswellia Medium Height Wooded Grassland

| Herbaceous Species | % Cover 81 | % Cover 83 | Δ% | % Composition 81 | % Composition 83 | Δ% |
|---|---|---|---|---|---|---|
| Hyparrhenia confinis | 41.25 | 55.63 | +14.38 | 58.93 | 82.41 | +23.48 |
| Setaria pumila | 8.13 | 4.38 | - 3.75 | 11.61 | 6.49 | - 5.12 |
| Schoenefeldia gracilis | 10.63 | 5.00 | - 5.63 | 15.18 | 7.41 | - 7.77 |
| Andropogon fastigiatus | 4.38 | 0.63 | - 3.75 | 6.25 | 0.93 | - 5.32 |
| Spermacoce radiata | 5.00 | 1.25 | - 3.75 | 7.14 | 1.85 | - 5.29 |
| Chloris prieuri | 0.63 | - | - 0.63 | 0.90 | - | - 0.90 |
| Pycreus pelophilus | - | 0.63 | + 0.63 | - | 0.93 | + 0.93 |
| Total Ground Cover | 70.02 | 67.53 | - 2.49 | - | - | - |
| Bare Soil | 19.97 | 21.22 | + 1.25 | - | - | - |
| Rock/Stones | 8.75 | 11.25 | + 2.50 | - | - | - |
| Litter | 1.25 | - | - 1.25 | - | - | - |

Method: Total enumeration of all species by height

| Woody Species | Number of Plants by Height Categories <1m 81 | <1m 83 | 1-3m 81 | 1-3m 83 | 3-5m 81 | 3-5m 83 | 5-7m 81 | 5-7m 83 | 7-12m 81 | 7-12m 83 |
|---|---|---|---|---|---|---|---|---|---|---|
| Combretum hartmanmnianum | 31 | 36 | 19 | 35 | 18 | 19 | 2 | 2 | - | - |
| Acacia garrardii | 38 | 117 | - | - | - | - | 4 | 4 | 1 | 1 |
| Boswellia papyrifera | - | - | - | - | 4 | 4 | 7 | 7 | 1 | 1 |
| Dichrostachys cinerea | 2 | 14 | - | - | - | - | - | - | - | - |
| Ziziphys spina-christi | 2 | 3 | - | - | - | - | - | - | - | - |
| Acacia seyal | 1 | 12 | - | - | - | - | - | - | - | - |
| Lannea humilis | 1 | - | - | - | - | - | - | - | - | - |
| Albizia amara | - | 1 | - | - | - | - | - | - | - | - |
| Combretum aculeatum | - | 1 | - | - | - | - | - | - | - | - |
| Balanites aegyptiaca | - | 1 | - | - | - | - | - | - | - | - |
| Maerua crassifolia | - | 3 | - | - | - | - | - | - | - | - |
| Total Number | 76 | 189 | 19 | 35 | 22 | 23 | 13 | 13 | 2 | 2 |
| Total Density/ha | 304 | 756 | 76 | 140 | 88 | 92 | 52 | 52 | 8 | 8 |

Table 2: Exclosure Vegetation Changes, Nuba Mountains, S. Kordofan

Exclosure No.: 2 Methods: Two-point frame/m on 2 transects each 40 m long
Soil Type: Reddish-White loamy sands on jebel footslopes Vegetation: Brachiaria - Lannea Short Wooded Grassland

| Herbaceous Species | % Cover 81 | % Cover 83 | △% | % Composition 81 | % Composition 83 | △% |
|---|---|---|---|---|---|---|
| Brachiaria xantholeuca | 31.25 | 22.50 | - 8.75 | 40.98 | 29.84 | -11.14 |
| Sporobolus festivus | 2.50 | 10.00 | + 7.50 | 3.28 | 12.90 | + 9.62 |
| Dactyloctenium aegyptium | 11.25 | 6.25 | - 5.00 | 14.75 | 8.06 | - 6.69 |
| Setaria pumila | 10.00 | 5.00 | - 5.00 | 13.11 | 6.45 | - 6.66 |
| Loudetia togoensis | 6.25 | 6.88 | + 0.63 | 8.20 | 8.87 | + 0.67 |
| Spermacoce senensis | 3.75 | 10.63 | + 6.88 | 4.92 | 13.71 | + 8.79 |
| Digitaria ternata & debilis | 5.00 | 4.38 | - 0.63 | 6.56 | 5.65 | - 0.91 |
| Hyparrhenia confinis | - | 3.13 | + 3.13 | - | 4.03 | + 4.03 |
| Chloris prieuri | 5.00 | 0.63 | - 4.37 | 6.56 | 0.88 | - 5.68 |
| Schoenefeldia gracilis | 1.25 | - | - 1.25 | 1.64 | - | - 1.64 |
| Juticia sp. | - | 1.25 | + 1.25 | - | 1.77 | + 1.77 |
| Total Ground Cover | 76.25 | 70.65 | - 5.60 | - | - | - |
| Bare Soil | 23.75 | 29.35 | + 5.60 | - | - | - |

| Woody*[1] Species | Number of Plants in Height Categoris <1m 81 | <1m 83 | 1-3m 81 | 1-3m 83 | 3-5m 81 | 3-5m 83 | 5-7m 81 | 5-7m 83 | 7-12m 81 | 7-12m 83 |
|---|---|---|---|---|---|---|---|---|---|---|
| Albizia amara | 6 | 6 | - | 2 | 2 | 1 | 1 | 2 | 1 | 1 |
| Lannea kerstingii | - | - | - | - | - | - | 1 | 1 | 1 | 1 |
| Sclerocarya birrea | - | - | - | - | - | - | - | - | 1 | 1 |
| Lannea humilis | 16 | 57 | 4 | 4 | - | - | - | - | - | - |
| Dichrostachys cinerea | 3 | 5 | - | 5 | - | - | - | - | - | - |
| Commiphora africana | 1 | 3 | - | 2 | - | - | - | - | - | - |
| Combretum hartmannianum | - | - | 3 | 3 | 2 | 2 | 1 | 1 | - | - |
| Combretum glutinosum | - | - | - | - | 2 | 2 | - | - | - | - |
| Ziziphus spina-christi | 17 | 20 | 3 | 3 | 2 | 2 | - | - | - | - |
| Acacia senegal | - | - | 1 | 1 | 2 | 2 | - | - | - | - |
| Balanites aegyptiaca | - | 1 | - | - | - | - | - | - | - | - |
| Ampelocissus africana | 1 | 1 | - | - | - | - | - | - | - | - |
| Total Number | 44 | 87 | 11 | 20 | 9 | 9 | 4 | 4 | 3 | 3 |
| Total Density/ha | 176 | 348 | 44 | 80 | 36 | 36 | 4 | 4 | 3 | 3 |

1 * Total enumeration of all woody plants by species above 10 cm in height

Table 3: Exclosure Vegetation Changes, Nuba Mountains, S. Kordofan

Exclosure No.:3 Methods: Two-point frame/m on 2 transects each 40 m long
Soil Type: Dark heavy cracking clays approximate to a small khor Vegetation: Hyparrhenia-Acacia seyal-Balanites Tall Wooded Grassland

| Herbaceous Species | % Cover 81 | % Cover 83 | Δ% | % Composition 81 | % Composition 83 | Δ% |
|---|---|---|---|---|---|---|
| Hyparrhenia pseudocymbaria | 36.89 | 28.75 | - 8.14 | 39.87 | 35.38 | - 4.49 |
| Hyparrhenia confinis | 16.25 | 41.25 | +25.00 | 17.57 | 50.77 | +33.20 |
| Brachiaria obtusiflora | 30.62 | 3.75 | -26.87 | 33.11 | 4.62 | -28.49 |
| Sorghum purpureo-sericeum | 4.38 | 5.63 | - 1.25 | 4.73 | 6.92 | + 2.19 |
| Rottboellia exaltata | 2.50 | - | - 1.25 | 1.35 | - | - 1.35 |
| Pennisetum pedicellatum | 1.25 | - | - 1.25 | 1.35 | - | - 1.35 |
| Setaria barbata | - | 0.63 | + 0.63 | - | 0.77 | + 0.77 |
| Chloris prieuri | 0.63 | - | - 0.63 | 0.68 | - | - 0.68 |
| Panicum sp | - | 1.25 | + 1.25 | - | 1.54 | + 1.54 |
| Total Ground Cover | 93.15 | 81.26 | -11.89 | - | - | - |
| Bare Soil | 4.35 | 18.74 | +14.39 | - | - | - |
| Litter | 2.50 | - | - 2.50 | - | - | - |

| Woody*[2] Species | Number of Plants by Height Categories <1m 81 | <1m 83 | 1-3m 81 | 1-3m 83 | 3-5m 81 | 3-5m 83 | 5-7m 81 | 5-7m 83 | 7-12m 81 | 7-12m 83 |
|---|---|---|---|---|---|---|---|---|---|---|
| Acacia seyal | 20 | 35 | 2 | 19 | - | - | - | - | - | - |
| Balanites aegyptiaca | 17 | 25 | 1 | 13 | - | - | - | - | 3 | 3 |
| Albizia amara | 11 | 9 | 8 | 20 | - | 2 | - | - | - | - |
| Dichrostachys cinerea | 4 | 26 | - | 3 | - | - | - | - | - | - |
| Acacia polyacantha | 3 | 5 | 2 | 6 | - | - | - | - | - | - |
| Tamarindus indica | - | - | - | - | - | - | - | - | 1 | 1 |
| Capparis tomentosa | 2 | 7 | - | - | - | - | - | - | - | - |
| Acacia senegal | - | 1 | - | - | - | - | 1 | 1 | - | - |
| Ziziphus spina-christi | - | 1 | 1 | 1 | - | - | - | - | - | - |
| Pilostigma reticulata | - | 2 | - | - | - | - | - | - | - | - |
| Combretum hartmannianum | - | 2 | - | - | - | - | - | - | - | - |
| Total Number | 57 | 113 | 14 | 62 | - | 2 | 1 | 1 | 4 | 4 |
| Total Density/ha | 228 | 452 | 56 | 248 | - | 8 | 4 | 4 | 16 | 16 |

2 * Total enumeration of all woody plant species above 10 cm in height

Table 4: Exclosure Vegetation Changes, Nuba Mountains, South Kordofan

Exclosure No.: 4 Methods: Two-point frame/m on 2 transects each 40m long

Soil Type: Red non-cracking clays with ironstone nodules - plains

Vegetation: Setaria-Hyparrhenia-Combretum-Albizia Medium Height Wooded Grassland

| Herbaceous Species | % Cover 81 | % Cover 83 | % Cover △% | % Composition 81 | % Composition 83 | % Composition △% |
|---|---|---|---|---|---|---|
| Hyparrhenia confinis | 12.50 | 11.88 | - 0.62 | 18.86 | 16.97 | - 1.89 |
| Setaria pumila | 21.88 | 25.00 | + 3.12 | 33.02 | 35.71 | + 2.69 |
| Loudetia togoensis | 15.62 | 9.38 | - 6.24 | 23.58 | 13.40 | + 2.69 |
| Chloris lamproparia | 3.75 | 5.63 | + 1.88 | 5.66 | 8.04 | + 2.38 |
| Digitaria ternata | 3.75 | 1.25 | - 2.50 | 5.66 | 1.79 | - 3.87 |
| Andropogon sp. | 3.13 | 4.38 | + 1.19 | 4.72 | 6.26 | + 1.54 |
| Schoenefeldia gracilis | 1.25 | - | - 1.25 | 1.89 | - | - 1.89 |
| Dactyloctenium aegyptium | 1.25 | 0.63 | - 0.62 | 1.89 | 0.89 | - 1.00 |
| Setaria verticillata | 1.25 | 0.63 | - 0.62 | 1.89 | 0.89 | - 1.00 |
| Brachiaria lata | 0.63 | 2.50 | + 1.57 | 0.94 | 3.57 | + 2.63 |
| Spermacoce senesis | 0.63 | 1.88 | + 1.25 | 0.94 | 2.68 | + 1.74 |
| Urochloa mossambicensis | - | 0.63 | + 0.63 | - | 0.89 | + 0.89 |
| Pennisetum pedicellatum | - | 5.00 | + 5.00 | - | 7.14 | + 7.14 |
| Justicia sp. | 0.63 | 1.25 | + 0.62 | 0.94 | 1.79 | + 0.85 |
| Total Ground Cover | 66.27 | 70.04 | + 3.77 | - | - | - |
| Litter | 5.00 | 3.13 | - 1.87 | - | - | - |
| Bare Soil | 28.73 | 26.83 | - 1.90 | - | - | - |

| Woody*[3] Species | Number of Plants by Height Categories <1m 81 | <1m 83 | 1-3m 81 | 1-3m 83 | 3-5m 81 | 3-5m 83 | 5-7m 81 | 5-7m 83 | 7-12m 81 | 7-12m 83 |
|---|---|---|---|---|---|---|---|---|---|---|
| Combretum hartmannianum | 8 | | - | | 3 | | - | | 2 | |
| Albizia amara | 3 | | - | | - | | 2 | | 1 | |
| Combretum glutinosum | - | | - | | 1 | | - | | - | |
| Combretum aculeatum | 8 | | 2 | | - | | - | | - | |
| Grewia villosa | 3 | | - | | - | | - | | - | |
| Grewia flavescens | 1 | | - | | - | | - | | - | |
| Terminalia laxiflora | 2 | | - | | - | | - | | 1 | |
| Stereospermum kunthianum | - | | - | | - | | 1 | | - | |
| Sclerocarya birrea | - | | - | | - | | - | | 1 | |
| Acacia gerrardii | - | | - | | - | | - | | 1 | |
| Dalbergia melanoxylon | - | | - | | 1 | | - | | - | |
| Acacia senegal | - | | 1 | | - | | - | | - | |
| Capparisu tomentosa | - | | 1 | | - | | - | | - | |
| Total Number | 25 | | 4 | | 5 | | 3 | | 6 | |
| Total Density/ha | 100 | | 16 | | 20 | | 12 | | 24 | |

[3] * Total enumeration of all woody plants by species above 10 cm in height. No measurements in 1983.

Table 5: Exclosure Vegetation Changes, Nuba Mountains, S. Kordofan

Exclosure No.: 5 Methods: Two-point frame/m on 2 transects each 40m long

Soil Type: Dark medium cracking clays - plains Vegetation: Hyparrhenia-Sorghum-Acacia seyal Tall Wooded Grassland

| Herbaceous Species | % Cover | | | % Composition | | |
|---|---|---|---|---|---|---|
| | 81 | 83 | Δ% | 81 | 83 | Δ% |
| Hyparrhenia pseudocymbaria | 54.38 | 65.00 | +10.62 | 76.99 | 94.55 | +17.56 |
| Sorghum purpureo-sericeum | 14.38 | 3.75 | -10.63 | 20.35 | 5.45 | -14.90 |
| Pennisetum pedicellatum | 1.88 | - | - 1.88 | 2.66 | - | - 2.66 |
| Total Ground Cover | 70.62 | 68.75 | - 1.87 | - | - | - |
| Litter | 17.50 | 18.13 | + 0.63 | - | - | - |
| Bare Soil | 11.87 | 13.12 | + 1.25 | - | - | - |

| Woody *4 Species | Number of Plants by Height Categories | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | <1m | | 1-3m | | 3-5m | | 5-7m | | 7-12m | |
| | 81 | 83 | 81 | 83 | 81 | 83 | 81 | 83 | 81 | 83 |
| Acacia seyal | 6 | | 2 | | 2 | | 6 | | 26 | |
| Acacia polyacantha | 10 | | 1 | | 1 | | 3 | | 3 | |
| Ziziphus spina-christi | 2 | | 2 | | 1 | | 2 | | - | |
| Combretum hartmannianum | 3 | | - | | - | | 1 | | - | |
| Acacia senegal | 1 | | - | | - | | - | | - | |
| Stereospermum kunthianum | - | | 1 | | - | | - | | - | |
| Albizia amara | 8 | | 4 | | - | | - | | - | |
| Total Number | 30 | | 10 | | 4 | | 12 | | 29 | |
| Total Density/ha | 120 | | 40 | | 16 | | 48 | | 116 | |

4 Total enumeration of all woody plants by species above 10m in height; no measurements taken in 1983.

Table 6: Exclosure Vegetation Changes, Nuba Mountains, S. Kordofan

Exclosure No.: 6 Methods: Two-point frame/m on 2 transects each 40m long
Soil Type: Brown non-cracking clays- plains Vegetation: *Hyparrhenia confinis*-Mixed Thorn and Broad-leaf Wooded Grassland

| Herbaceous Species | % Cover 81 | % Cover 83 | Δ% | % Composition 81 | % Composition 83 | Δ% |
|---|---|---|---|---|---|---|
| *Hyparrhenia confinis* | 59.37 | 58.11 | - 1.26 | 95.00 | 96.88 | + 1.88 |
| *Pennisetum pedicellatum* | 0.63 | 0.63 | none | 1.00 | 1.04 | + 0.04 |
| *Setaria barbata* | 1.88 | 1.25 | - 0.63 | 3.00 | 2.08 | - 0.92 |
| *Sehima ischaemoides* | 0.63 | - | - 0.63 | 1.00 | 1.04 | + 0.04 |
| Total Ground Cover | 62.51 | 59.99 | - 2.52 | - | - | - |
| Litter | 16.25 | 8.13 | - 8.12 | - | - | - |
| Bare Soil | 21.25 | 30.63 | + 9.38 | - | - | - |
| Rocks/Stones | - | 1.25 | + 1.25 | - | - | - |

| Woody*[5] Species | Number of Plants by Height Categories <1m 81 | <1m 83 | 1-3m 81 | 1-3m 83 | 3-5m 81 | 3-5m 83 | 5-7m 81 | 5-7m 83 | 7-12m 81 | 7-12m 83 |
|---|---|---|---|---|---|---|---|---|---|---|
| *Acacia seyal* | 59 | | 32 | | 12 | | 10 | | 3 | |
| *Dichrostachys cinerea* | 42 | | 5 | | 1 | | - | | - | |
| *Combretum hartmannianum* | 7 | | 10 | | 3 | | 1 | | 1 | |
| *Acacia polyacantha* | 6 | | 2 | | - | | 1 | | 1 | |
| *Albizia amara* | 5 | | - | | - | | - | | - | |
| *Acacia senegal* | 7 | | 4 | | 1 | | 1 | | 1 | |
| *Acacia gerrardii* | 4 | | 3 | | 1 | | - | | 2 | |
| *Anogeissus leiocarpus* | - | | - | | - | | 2 | | 2 | |
| *Commiphora africana* | 5 | | - | | - | | - | | - | |
| *Lannea humilis* | 16 | | - | | - | | - | | - | |
| *Grewia villosa* | 1 | | - | | - | | - | | - | |
| *Ziziphus spina-christi* | 2 | | 1 | | - | | - | | - | |
| *Lannea schweinfurthii* | - | | - | | - | | 1 | | - | |
| *Dalbergia melanoxylon* | 1 | | - | | - | | - | | - | |
| Total Number | 155 | | 57 | | 18 | | 15 | | 10 | |
| Total Density/ha | 620 | | 228 | | 72 | | 60 | | 40 | |

[5] * Total enumeration of all woody plants by species above 10 cm in height; no measurements taken in 1983.

Table 7: Exclosure Vegetation Changes, Nuba Mountains, S. Kordofan

Exclosure No.: 7 Methods: Two-point frame/m on 2 transects each 10m long
Soil Type: Dark heavy cracking clays - plains Vegetation: Sehima-Setaria-Sorghum-Balanites Medium Tall Wooded Grassland

| Herbaceous Species | % Cover 81 | % Cover 83 | % Cover Δ% | % Composition 81 | % Composition 83 | % Composition Δ% |
|---|---|---|---|---|---|---|
| Sehima ischaemoides | 35.62 | 27.50 | - 8.12 | 39.86 | 30.14 | - 9.72 |
| Setaria incrassata | 21.25 | 35.00 | +13.75 | 23.78 | 38.36 | +14.58 |
| Sorghum purpureo-sericeum | 22.50 | 24.38 | + 1.88 | 25.18 | 26.71 | + 1.53 |
| Ischaemum afrum | 2.50 | 2.50 | none | 2.80 | 2.74 | - 0.06 |
| Cymbopogon nervatus | 1.88 | - | - 1.88 | 2.10 | - | - 2.10 |
| Aristida hordaceae | 0.63 | - | - 0.63 | 0.70 | - | - 0.70 |
| Rhyncosia minima | 5.00 | 1.88 | - 3.12 | 5.59 | 2.05 | - 3.54 |
| Total Ground Cover | 89.38 | 91.26 | + 1.88 | - | - | - |
| Litter | 3.75 | 3.12 | - 0.63 | - | - | - |
| Bare Soil | 6.87 | 5.62 | - 1.25 | - | - | - |

| Woody *6 Species | Number of Plants by Height Categories <1m 81 | <1m 83 | 1-3m 81 | 1-3m 83 | 3-5m 81 | 3-5m 83 | 5-7m 81 | 5-7m 83 | 7-12m 81 | 7-12m 83 |
|---|---|---|---|---|---|---|---|---|---|---|
| Balanites aegyptiaca | 3 | | - | | - | | - | | 1 | |
| Acacia seyal | 7 | | - | | - | | - | | - | |
| Pilostigma reticulata | 4 | | - | | - | | - | | - | |
| Ziziphus spina-christi | 1 | | - | | - | | - | | - | |
| Dichrostachys cinerea | 1 | | - | | - | | - | | - | |
| Total Number | 16 | | - | | - | | - | | - | |
| Total Density/ha | 64 | | - | | - | | - | | 4 | |

6 *Total enumeration of all woody plants by species above 10 cm in height; no measurement in 1983.

Table 8: Enclosure Vebetation Changes, Nuba Mountains, S. Kordofan
Exclosure No.: 8 Methods: Two-point frame/m on 2 transects each 40m long

Soil Type: Light brown coarse sandy clay loams - Footslope bottom

Vegetation: Aristida-Acacia Short Wooded Grassland

| Herbaceous Species | % Cover 81 | % Cover 83 | Δ% | % Composition 81 | % Composition 83 | Δ% |
|---|---|---|---|---|---|---|
| Aristida funiculata | 25.00 | 33.12 | +11.25 | 34.78 | 38.41 | + 7.98 |
| Aristida hordaceae | 13.12 | 9.38 | - 3.74 | 18.26 | 10.87 | - 7.39 |
| Aristida adscenionis | 2.50 | 4.37 | + 1.87 | 3.48 | 5.07 | + 1.59 |
| Hyparrhenia confinis | 10.62 | 14.38 | + 3.76 | 14.78 | 16.67 | + 1.89 |
| Schoenefeldia gracilis | 12.50 | 11.25 | - 4.37 | 17.34 | 13.04 | - 4.35 |
| Chloris lamproparia | 3.75 | 3.75 | none | 5.22 | 4.35 | - 0.87 |
| Sehima ischaemoides | - | 3.75 | + 3.75 | - | 4.35 | + 4.35 |
| Setaria pumila | 1.88 | 2.50 | + 0.63 | 2.61 | 2.90 | + 0.29 |
| Spermacoce senesis | 1.88 | 1.88 | none | - | 2.17 | - 0.44 |
| Pennisetum pedicellatum | - | 1.25 | + 1.25 | - | 1.45 | + 1.45 |
| Crotalaria microcarpa | - | 0.63 | + 0.63 | - | 0.72 | + 0.72 |
| Sporobolus festivus | 0.63 | 0.63 | none | 0.87 | 0.72 | - 0.15 |
| Total Ground Cover | 71.88 | 86.90 | +15.02 | - | - | - |
| Litter | 0.63 | 0.63 | none | - | - | - |
| Bare Soil | 27.49 | 12.47 | -15.02 | - | - | - |

| Woody*[7] Species | Number of Plants by Height Categories <1m 81 | <1m 83 | 1-3m 81 | 1-3m 83 | 3-5m 81 | 3-5m 83 | 5-7m 81 | 5-7m 83 | 7-12m 81 | 7-12m 83 |
|---|---|---|---|---|---|---|---|---|---|---|
| Acacia senegal | 31 | | 17 | | 2 | | - | | - | |
| Acacia seyal | 3 | | 4 | | 4 | | - | | - | |
| Acacia gerrardii | 3 | | 3 | | - | | 1 | | 1 | |
| Dichrostachys cinerea | 42 | | 12 | | - | | - | | - | |
| Albizia amara | 14 | | 3 | | - | | - | | - | |
| Combretum aculeatum | 5 | | 3 | | - | | - | | - | |
| Combretum hartmannianum | - | | 3 | | - | | - | | - | |
| Commiphora africana | 2 | | 2 | | 1 | | - | | - | |
| Dalbergia malonoxylon | 1 | | - | | 1 | | - | | - | |
| Anogeissus leiocarpus | - | | - | | 1 | | - | | - | |
| Sclerocarya birrea | - | | - | | 1 | | - | | - | |
| Total Number | 101 | | 47 | | 10 | | 1 | | 1 | |
| Total Density/ha | 404 | | 188 | | 40 | | 4 | | 4 | |

7 * Total enumeration of all woody plants by species above 10 cm in height; no measurements taken in 1983.

Table 9: Exclosure Vegetation Changes, Nuba Mountains, S. Kordofan

Exclosure No.: 9 Methods: Two-point frame/m on 2 transects each 40m long
Soil Type: Red-brown sandy loamy clays - jebel footslopes. Vegetation: Hyparrhenia confinis - Combretum - Pilostigma Wooded Grassland.

| Herbaceous Species | % Cover 81 | % Cover 83 | Δ% | % Composition 81 | % Composition 83 | Δ% |
|---|---|---|---|---|---|---|
| Hyparrhenia confinis | 46.88 | 56.25 | + 9.37 | 58.59 | 61.64 | + 3.05 |
| Loudetia togoensis | 15.62 | 7.50 | - 8.12 | 19.53 | 8.22 | -11.31 |
| Sporobolus festivus | 2.50 | 3.75 | + 1.25 | 3.12 | 4.11 | + 0.99 |
| Heteropogon contortus | 1.88 | 3.75 | + 1.88 | 2.34 | 4.11 | + 1.77 |
| Panicum callosum | - | 1.88 | + 1.88 | - | 2.05 | + 2.05 |
| Rottboellia exaltata | - | 1.88 | + 1.88 | - | 2.05 | + 2.05 |
| Crotalaria microcarpa | 5.00 | 1.88 | - 3.12 | 6.25 | 2.05 | - 4.20 |
| Indigofera stenophylla | 1.88 | 9.38 | + 7.50 | 2.34 | 10.27 | + 7.93 |
| Indigofera astragalina | - | 1.25 | + 1.25 | - | 1.37 | + 1.37 |
| Cassia absus | - | 0.63 | + 0.63 | - | 0.68 | + 0.68 |
| Cassia mimosoides | 0.63 | 1.88 | + 1.25 | 0.78 | 2.05 | + 1.27 |
| Spermacoce senensis | 2.50 | 1.25 | - 1.25 | 3.12 | 1.37 | - 1.75 |
| Polycarpea corymbosa | 3.12 | - | - 3.12 | 3.91 | - | - 3.91 |
| Total Ground Cover | 80.01 | 91.28 | +11.27 | - | - | - |
| Litter | - | 6.25 | + 6.25 | - | - | - |
| Bare Soil | 19.99 | 2.47 | -17.52 | - | - | - |

| Woody* Species | Number of Plants by Height Categories <1m 81 | <1m 83 | 1-3m 81 | 1-3m 83 | 3-5m 81 | 3-5m 83 | 5-7m 81 | 5-7m 83 | 7-12m 81 | 7-12m 83 |
|---|---|---|---|---|---|---|---|---|---|---|
| Combretum hartmannianum | 82 | | 17 | | - | | 2 | | - | |
| Piliostigma reticulatum | 7 | | 31 | | - | | - | | - | |
| Dichrostachys cinerea | 12 | | - | | - | | - | | - | |
| Gardenia lutea | 2 | | 2 | | - | | - | | - | |
| Balanites aegyptiaca | 2 | | - | | - | | - | | - | |
| Xeromphis nilotica | - | | - | | 1 | | - | | - | |
| Acacia senegal | 1 | | - | | - | | - | | - | |
| Ximenia americana | - | | 1 | | - | | - | | - | |
| Prosopia africana | - | | - | | - | | 1 | | - | |
| Albizia amara | - | | - | | - | | 1 | | - | |
| Total Number | 106 | | 51 | | 1 | | 3 | | - | |
| Total Density/Ha | 424 | | 204 | | 4 | | 12 | | - | |

* Total enumeration of all woody plants by species above 10 cm in height

Table 10: Exclosure Vegetation Changes, Nuba Mountains, S. Kordofan

Exclosure No.: 10 Methods: Two-point frame/m on 2 transects each 40m long
Soil Type: Black heavy cracking clays in inundated depressions. Vegetation: Echinochloa-Oryza Tall Seasonal Swamp Grassland.

| Herbaceous Species | % Cover | | | % Composition | | |
|---|---|---|---|---|---|---|
| | 81 | 83 | Δ% | 81 | 83 | Δ% |
| Echinochloa Pyramidalis | 41.86 | 35.00 | - 6.88 | 41.88 | 35.90 | - 5.98 |
| Oryza longistaminata | 50.00 | 45.00 | - 5.00 | 50.00 | 46.15 | - 3.85 |
| Hygrophila sp. | 1.25 | 13.12 | +11.87 | 1.25 | 13.46 | +12.21 |
| Thalia welwitchii | - | 3.12 | + 3.12 | - | 3.20 | + 3.20 |
| Cyperus exaltatus | 6.25 | 0.63 | + 5.67 | 6.25 | 0.64 | + 5.66 |
| Aecheminoides indica | 0.63 | - | - 0.63 | 0.63 | - | - 0.63 |
| Conchorus sp. | - | 0.63 | + 0.63 | - | 0.64 | + 0.64 |
| Total Ground Cover | 100.00 | 97.50 | -2.50 | - | - | - |
| Litter | 0.63 | 0.63 | none | - | - | - |
| Bare Soil | - | 1.87 | +1.87 | - | - | - |

| Woody* Species | Number of Plants by Height Categories | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | <1m | | 1-3m | | 3-5m | | 5-7m | | 7-12m | |
| | 81 | 83 | 81 | 83 | 81 | 83 | 81 | 83 | 81 | 83 |
| Acacia seyal | - | | 1 | | - | | - | | - | |
| Total Number | - | | 1 | | - | | - | | - | |
| Total Density/Ha | - | | 4 | | - | | - | | - | |

* Total enumeration by species and height

Table 11: Vegetation Changes Monitored from Permanent Transects Under Open-Range Conditions, Nuba Mountain Region

Location: Kadugli Research Station Soil Type: Dark cracking clays - plains

Methods: (1) Herbaceous - 2-point frame every meter for cover and frequency on a 100m transect

(2) Woody - Total enumeration by species and height on a belt transect 100m x 6m

| Herbaceous Species | % Cover 81 | % Cover 83 | % Cover Δ% | % Composition by Cover 81 | % Composition by Cover 83 | % Composition by Cover Δ% |
|---|---|---|---|---|---|---|
| Cymbopogon nervatus | 37.50 | 41.60 | + 4.40 | 40.76 | 49.06 | + 8.30 |
| Brachiaria obtusiflora | 23.00 | 9.37 | -13.63 | 25.00 | 11.01 | -13.99 |
| Rottboellia exaltata | 15.50 | 8.94 | - 6.56 | 16.85 | 10.52 | - 6.33 |
| Aristida hordaceae | 6.50 | 14.46 | + 7.97 | 7.07 | 17.02 | + 9.95 |
| Sehima ischaemoides | 3.50 | 3.83 | + 0.33 | 3.80 | 4.51 | + 0.71 |
| Sorghum purpureo-sericeum | 2.00 | 3.83 | + 2.83 | 2.17 | 4.51 | + 2.34 |
| Hyparrhenia pseudocymbaria | 4.00 | 2.98 | - 1.02 | 4.35 | 3.50 | - 0.85 |
| Total Ground Cover | 92.00 | 85.00 | - 7.00 | - | - | - |
| Litter | 2.00 | 0.00 | - 2.00 | - | - | - |
| Bare Soil | 6.00 | 15.00 | + 9.00 | - | - | - |

| Woody* Species | Enumeration in 1982; to be re-sampled in 1984 Height Cataegories <1m | 1-2m | 2-3m | 3-5m | 5-7m | 7-9m | 9m |
|---|---|---|---|---|---|---|---|
| Acacia polyacantha | 67 | 6 | - | - | - | - | - |
| Dichrostachys cinerea | 32 | 6 | 1 | - | - | - | - |
| Cephalocroton cordofanus | 11 | 5 | - | - | - | - | - |
| Acacia seyal | 4 | 2 | 1 | 3 | 2 | - | - |
| Balanites aegyptiaca | 10 | - | - | - | - | 1 | - |
| Combretum aceleatum | - | 1 | - | - | - | - | - |
| Commiphora africana | 1 | - | - | - | - | - | - |
| Capparis tomentosa | 2 | - | - | - | - | - | - |
| Total Number | 127 | 20 | 2 | 3 | 2 | 1 | - |
| Total Density/Ha | 2117 | 333 | 33 | 50 | 33 | 17 | - |

Table 12: Vegetation Changes Monitored from Permanent Transects Under Open-Range Conditions, Nuba Mountain Region

Location: Bilinya Soil Type: Red-brown sandy clays - footslopes

Methods: (1) Herbaceous - 2-point frame every meter for cover and frequency on a 100m transect

(2) Woody - Total enumeration by species and height on a belt transect 80m x6m

| Herbaceous Species | % Cover | | | % Composition by Cover | | |
|---|---|---|---|---|---|---|
| | 81 | 83 | Δ% | 81 | 83 | Δ% |
| Hyparrhenia confinis | 35.63 | 42.50 | + 6.87 | 44.89 | 58.62 | +13.73 |
| Sporobolus festivus | 13.13 | 10.00 | - 3.13 | 16.67 | 13.79 | - 2.88 |
| Loudeta togoensis | 1.25 | 3.12 | + 1.87 | 1.59 | 4.31 | 2.72 |
| Panicum callosum | 7.50 | 1.88 | - 5.62 | 9.52 | 2.59 | - 6.93 |
| Commelina sp. | 6.25 | 10.00 | + 3.75 | 7.94 | 13.79 | + 5.85 |
| Blepharis linarifolia | 4.38 | 2.50 | - 1.88 | 5.56 | 3.45 | - 2.11 |
| Crotalaria microcarpa | 4.38 | 1.88 | - 2.50 | 5.56 | 2.59 | - 2.97 |
| Indigofera stenophylla | 2.50 | 0.63 | - 1.87 | 3.17 | 0.86 | - 2.31 |
| Indigofera astragalina | 1.88 | - | - 1.88 | 2.38 | - | - 2.38 |
| Cassia mimosoides | 1.88 | - | - 1.88 | 2.38 | - | - 2.38 |
| Total Ground Cover | 78.75 | 72.51 | - 6.24 | - | - | - |
| Litter | 1.25 | - | - 125 | - | - | - |
| Bare Soil | 20.00 | 27.49 | + 7.49 | - | - | - |

| Woody* Species | Enumeration in 1982; to be re-sampled in 1984 Height Cataegories | | | | | | |
|---|---|---|---|---|---|---|---|
| | <1m | 1-2m | 2-3m | 3-5m | 5-7m | 7-9m | 9m |
| Combretum hartmannianum | 97 | 14 | 5 | 2 | - | 1 | - |
| Piliostigma reticulatum | - | 4 | 2 | - | - | - | - |
| Ziziphus spina-christi | 1 | - | 1 | - | - | - | - |
| Ozoroa insignis | - | - | 1 | - | - | - | - |
| Dichrostachys cinerea | 1 | - | - | - | - | - | - |
| Acacia seyal | 1 | - | - | - | - | - | - |
| Total Number | 100 | 18 | 9 | 2 | - | 1 | - |
| Total Density/Ha | 2083 | 375 | 187 | 42 | - | 21 | - |

Table 13: Comparison of Herbaceous Composition on Grazed and Ungrazed sides of a Jebel, Nuba Mountains, South Kordofan

Location: Kurgul area  Soil Type: Rocky coarse-textured sandy loams and clays on steep jebel hillsides

Methods: Two-point frame every meter along a 60m transect in both sites

| Herbaceous Species | % Cover | | | % Composition | | |
|---|---|---|---|---|---|---|
| | Grazed | Ungrazed | Δ% | Grazed | Ungrazed | Δ% |
| *Hyparrhenia confinis* | 25.83 | 66.67 | +40.84 | 36.47 | 81.63 | +45.16 |
| *Setaria pumila* | 15.00 | 0.83 | -14.17 | 17.65 | 1.02 | -16.63 |
| *Brachiaria lata* | 6.70 | - | - 6.70 | 9.41 | - | - 9.41 |
| *Panicum callosum* | 10.83 | 10.00 | - 0.83 | 15.29 | 12.25 | - 3.04 |
| *Dactyloctenium aegyptium* | 2.50 | - | - 2.50 | 3.53 | - | - 3.53 |
| *Zornia glochidiata* | 4,17 | - | - 4.17 | 5.88 | - | - 5.88 |
| *Crotalaria microcarpa* | 1.67 | - | - 1.67 | 2.35 | - | - 2.35 |
| *Indigofera stenophylla* | 1.67 | - | - 1.67 | 2.35 | - | - 2.35 |
| *Cassia absus* | 0.83 | - | -0.83 | 1.18 | - | - 1.18 |
| *Aspilia ciliata* | 0.83 | 4.17 | 3.34 | 1.18 | 5.10 | 3.92 |
| *Polycarpea corybosa* | 0.83 | - | - 0.83 | 1.18 | - | - 1.18 |
| Total Ground Cover | 70.86 | 81.67 | +10.81 | - | - | - |
| Litter | - | - | - | - | - | - |
| Bare Soil/Rock | 29.14 | 18.33 | -10.81 | - | - | - |

Table 14: Studies of Herbaceous and Woody Composition with Treatments of Fire, Hand-thinning, and Browsing

Soil Type: Dark cracking clays  Plot No. and Size: 1 (100 x 50m)

Methods of Plant Enumeration: (1) Herbaceous - 2-point frame every meter pm a 50m transect

(2) Woody - Total enumeration on a belt transect 50 x 4m

Treatment: Early dry-season burn yearly

| Herbaceous Species | % Cover | | | % Composition by Cover | | |
|---|---|---|---|---|---|---|
| | 81 | 83 | Δ% | 81 | 83 | Δ% |
| Cymbopogon nervatus | 41.00 | 9.00 | -32.00 | 48.24 | 10.34 | -37.90 |
| Schima ischaemoides | 25.00 | 52.00 | +27.00 | 29.41 | 59.77 | +30.36 |
| Sorghum purpureo-sericeum | 15.00 | 22.00 | + 7.00 | 17.65 | 25.29 | + 7.64 |
| Brachiaria obtusiflora | 4.00 | 4.00 | none | 4.71 | 4.60 | - 0.11 |
| Rottboellia exaltata | 1.00 | - | - 1.00 | 1.18 | - | - 1.18 |
| Total Ground Cover | 85.00 | 87.00 | + 2.00 | - | - | - |
| Litter | 1.00 | - | - 1.00 | - | - | - |
| Bare Soil | 14.00 | 13.00 | - 1.00 | - | - | - |

| Woody Species (1982) | Plant enumeration prior to treatment with re-sampling to be done in 1984 Height Cataegories | | | | | | |
|---|---|---|---|---|---|---|---|
| | <1m | 1-2m | 2-3m | 3-5m | 5-7m | 7-9m | 9m |
| Acacia seyal | 4 | 8 | 7 | 2 | 1 | - | - |
| Dichrostachys cinerea | 34 | 56 | 11 | - | - | - | - |
| Acacia polyacantha | - | 2 | - | - | - | - | - |
| Cephalocroton cordofanus | 10 | 1 | - | - | - | - | - |
| Combretum aculeatum | 2 | - | - | - | - | - | - |
| Albizia amara | 9 | 12 | - | - | - | - | - |
| Capparis tomentosa | 17 | - | - | - | - | - | - |
| Total Number | 76 | 80 | 18 | 2 | 1 | - | - |
| Total Density/Ha | 3800 | 4000 | 900 | 100 | 50 | - | - |

Table 15: Studies of Herbaceous and Woody Composition with Treatments of Fire, Hand-thinning, and Browsing

Soil Type: Dark cracking clays  Plot No. and Size: 5 (100 x 50m)

Methods of Plant Enumeration: (1) Herbaceous - 2-point frame every meter pm a 50m transect
(2) Woody - Total enumeration on a belt transect 50 x 4m

Treatment: Early dry-season burn yearly (Rep. No.2)

| Herbaceous Species | % Cover 81 | % Cover 83 | % Cover Δ% | % Composition by Cover 81 | % Composition by Cover 83 | % Composition by Cover Δ% |
|---|---|---|---|---|---|---|
| Cymbopogon nervatus | 29.00 | 25.00 | - 4.00 | 32.95 | 27.47 | - 5.48 |
| Sehima ischaemoides | 21.00 | 38.00 | +17.00 | 23.86 | 41.76 | +17.90 |
| Sorghum purpureo-sericeum | 17.00 | 18.00 | + 1.00 | 19.32 | 19.78 | + 0.46 |
| Aristida hordaceae | 12.00 | 8.00 | - 4.00 | 13.64 | 8.79 | - 4.85 |
| Brachiaria obtusiflora | 3.00 | - | - 3.00 | 3.41 | - | - 3.41 |
| Rottboellia exaltata | 2.00 | 1.00 | - 1.00 | 2.27 | 1.10 | - 1.17 |
| Spermacoce senensis | 1.00 | - | - 1.00 | 1.14 | - | - 1.14 |
| Ryncosia minima | 2.00 | - | - 2.00 | 2.27 | - | - 2.27 |
| Pennisetum pedicellatum | 1.00 | - | - 1.00 | 1.14 | - | - 1.14 |
| Panicum sp. | - | 1.00 | + 1.00 | - | 1.10 | + 1.10 |
| Total Ground Cover | 88.00 | 91.00 | + 3.00 | - | - | - |
| Litter | 1.00 | - | - 1.00 | - | - | - |
| Bare Soil | 11.00 | 9.00 | - 2.00 | - | - | - |

| Woody Species (1982) | Plant enumeration prior to treatment with re-sampling to be done in 1984 Height Cataegories <1m | 1-2m | 2-3m | 3-5m | 5-7m | 7-9m | 9m |
|---|---|---|---|---|---|---|---|
| Acacia seyal | 7 | 7 | 9 | 28 | - | - | - |
| Dichrostachys cinerea | 29 | 3 | 5 | - | - | - | - |
| Acacia polyacantha | - | - | 1 | 7 | - | - | - |
| Cephalocroton cordofanus | 13 | 6 | - | - | - | - | - |
| Combretum aculeatum | 2 | 1 | - | - | - | - | - |
| Albizia amara | 5 | 1 | - | - | - | - | - |
| Capparis tomentosa | 1 | - | - | - | - | - | - |
| Total Number | 57 | 18 | 14 | 35 | - | - | - |
| Total Density/Ha | 2850 | 900 | 700 | 1750 | - | - | - |