Where vegetation ecology is concerned, the aerial surveys of 1978 and 1981 have provided quantitative as well as qualitative data for those plants that can be seen in the photographs. Components of strata below the canopy, where this is continuous, are not able to be satisfactorily detected.

The vegetation data obtained included species recognition and vitality as well as such criteria of abundance as density, cover and frequency. These parameters have been stored or presented as such or used in calculations of importance values for the various components.

Density, as numbers of individuals per unit area presented difficulties since individuals were not always able to be distinguished. Isolated or loosely assembled plants were not difficult to count, but gregarious species or those in dense pure stands offered problems which were partly overcome by referring to numbers as numbers of individuals or clumps/tufts, the latter which were considered, for woody and subwoody plants, in as small as possible a discrete unit.

Cover or crown spread was easily determined if this concerned upper canopy or open community species. For trees, crown spread would be a more accurate term since the crowns do not always have 100 percent true cover. For low-growing vegetation, wherever possible, cover is as stated.

Frequency, as presence of an entity in a number of samples expressed as a percentage of the total number of sample of canopy or open community components was readily determined. As a value it could be improved by subsampling, especially of the quadrats each of which was 1 hectare.

Vitality and changes thereof were best determined from stereoscopic viewing of stereo pairs of colour infra-red transparencies of one date, or one photograph of one date simultaneously viewed with another photograph of the same subject at the second date.

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10. AVAILABILITY, QUALITY AND UTILIZATION OF THE RIVERINE VEGETATION OF THE LOWER KUISEB AND CANYON AREA

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INTRODUCTION

In view of the importance of the Kuiseb riverine vegetation as a forage resource for game during dry periods, it was important to determine the forage production and availability of key forage plants. Other factors of importance included species preference, area preference and the influence of the availability of water on the use of riverine vegetation. Furthermore, the influence of the domestic stock of the Topnaar Hottentot communities on riverine vegetation and on the utilization of this by game animals was important.

The boundaries of the study area were determined as 78 km upstream from Gobabeb to 30 km downstream from Gobabeb. The most important woody species within this area included Acacia albida, A erioloba, Euclea pseudebenus, Tamarix usneoides and Salvadora persica, of which A albida and A erioloba were considered the most important forage plants.

Although the river flowed very weakly during the study period, the canyon area was flooded annually as follows:

1979: during February and March to approximately 30 km upstream of Gobabeb

1980: during March to approximately 50 km upstream of Gobabeb

1981: during April to approximately 10 km upstream of Gobabeb

1982: during March to approximately 35 km upstream of Gobabeb

During the last three years the flow was, however, very weak.

The larger herbivores of the area comprised goats, sheep, cattle and donkeys of the Topnaar Hottentots as well as oryx, springbok, steenbok, klipspringers and ostriches. Zebras visited the river only for water. A few kudus were also noted in the study area.

PHENOLOGY

Observations on the presence or absence of new shoot growth, inflorescences, fruit and green pods were made on marked trees in the vicinity of Gobabeb. The pattern of pod fall was determined for trees in exclosures.

The peak flowering period for *A albida* was found to be June to August with a few inflorescences present until February. Green pods peak between September and October with some still being found as late as March. Although pods can fall all through the year, the greatest pod fall occurs during December and January.

The flowering period of *A erioloba* peaked in November to January, but trees in full flower can be found throughout the year. Pods fall throughout the year but with the peak fall during March to August (Table 1).

Table 1. Phenophases of woody species in the vicinity of Gobabeb.

	J	F	M	A	M	J	J	A	S	O	N	D
Acacia albida												
Shoot growth	x	x	x							x	x	x
Inflorescence	x	x				x	x*	x*	x	x	x	x
Green pods	x	x	x					x	x*	x*	x	x
Pod fall	x*	x	x	x	x	x	x	x			x*	x*
Acacia erioloba												
Shoot growth	x	x	x						x	x	x	x
Inflorescence	x*	x	x	x			x	x	x	x	x*	x*
Green pods	x*	x*	x*	x*	x	x	x	x	x	x	x	x
Pod fall	x	x	x*	x*	x*	x*	x*	x*		x	x	x
Euclea pseudebenus												
Shoot growth	x	x	x	x								
Inflorescence								x	x	x	x	
Fruit	x	x	x	x						x	x	x
Salvadora persica												
Shoot growth	x	x	x	x								
Inflorescence	x	x	x	x	x							
Fruit			x	x	x	x	x					
Tamarix usneoides												
Shoot growth	x	x	x	x								
Inflorescence				x								

x = present
x* = peak time

FORAGE AVAILABILITY

Pods were collected under trees within exclosures, dried and weighed. Leaf production and availability was determined bi-annually by manually removing the leaves of branches within exclosures. The oven dry mass of the leaves was determined. The leaves were collected in two strata, from 0 to 1,1 m and from 1,1 to 1,8 m. The trees were classified within three classes in terms of their size and form, namely class 1 - trees higher than 3 m with a round umbrella form; class 2 - trees higher than 3 m with an upright form; and class 3 - trees lower than 3 m (generally with an upright growth form).

The availability of *A albida* pods showed a seasonal peak during November to January while the seasonal peak of *A erioloba* occurred between March and August. The two species therefore complement one another in terms of pod availability. The annual pod availability of *A albida* and *A erioloba* in different communities is indicated in Tables 1, 2 and 3. Class 1 trees provide the greatest contribution to pod production.

Table 2. Average annual pod availability (kg ha^{-1}) of *Acacia albida* in different communities.

Community	Class 1 1980/81	1981/82	1979/80	Class 2 1981/81	1981/82
Riverbed	330	35	0,86	0,18	0,05
A albida	7 623	839	12,78	2,30	0,77
A erioloba	43	3	0,00	0,00	0,00
A albida - A erioloba	1 761	193	1,11	0,23	0,06
Tamarix - A albida	2 257	247	0,00	0,00	0,00
Tamarix - A erioloba	38	3	0,00	0,00	0,00
Tamarix	58	5	0,12	0,05	0,003
Euclea	304	32	0,00	0,00	0,00
Salvadora	38	3	0,82	0,18	0,05
All communities	594	64	2,06	0,40	0,12

Table 3. Average annual pod availability (kg ha^{-1}) of *Acacia erioloba* in different communities.

Community	Class 1 1979/80	1980/81	1981/82	Class 2 1980/81	1981/82
Riverbed	11	1	4	0,00	0,00
A albida	115	11	50	0,00	0,01
A erioloba	289	28	126	0,00	0,07
A albida - A erioloba	29	2	12	0,00	0,01
Tamarix - A albida	238	23	104	0,00	0,01
Tamarix - A erioloba	362	35	145	0,00	0,07
Tamarix	8	0	3	0,00	0,02
Euclea	0	0	0	0,00	0,00
Salvadora	2	0	1	0,00	0,003
All communities	146	14	64	0,00	0,03

Leaf availability shows a seasonal peak during February, which corresponds with the phenological observations of shoot growth and leaf development. Despite the large size of many of the acacia trees, the proportion of leaves which are available to the large herbivores is very limited. Most of the branches were out of the reach of the animals, while many of these branches within reach had died off. The increased utilization of Salvadora leaves during the dry period indicated the importance of Salvadora as a drought reserve during the winter of 1982 when 291 kg per hectare of Salvadora leaves were available.

UTILIZATION AND SPECIES PREFERENCE

Utilization was determined on eight occasions using the estimation technique described by Walker (1976). Oryx grazing showed a seasonal pattern (Figure 1). Forage utilization by goats did not show such a clear seasonal pattern due to the dry circumstances and because they were not moved from their grazing areas. The utilization by goats showed a decrease towards the limits of their grazing area with a peak around water points. This tendency is particularly clear in the case of Tamarix usneoides. Both oryx and goats exhibited preference for A albida, A erioloba and Euclea pseudebenus. As the drought advanced, the utilization of Salvadora persica increased.

AREA SELECTION

Area selection was determined by making a monthly game and domestic stock count in the study area. The area selection by goats was determined by the distance they could cover in their daily wanderings from their holding pens, and by the availability of forage. During times of peak pod fall, especially of A albida, the grazing area of goats was much smaller than otherwise. During dry conditions the diminishing availability of food led to their having much expanded grazing areas.

Oryx, springbok and ostriches exhibited preferences for specific areas. It was notable that their grazing areas did not overlap with those of the goats, although springbok and ostriches frequently used the same grazing area.

CHEMICAL COMPOSITION OF THE FORAGE

Samples of the five most important woody species were collected monthly and analysed for moisture content, digestible organic matter, crude protein, acid-digestible fibre and ash. The maximum and minimum nutrient values of five species of woody plants are indicated in Table 4. The maximum and minimum values of digestible organic matter, crude protein and acid digestible fibre show a large variation and this is due to a decrease with the advance of dry conditions. The moisture content was largely influenced by the environmental conditions and in particular fog. Dry pods normally had a moisture content of 3 to 5 percent but during foggy weather this could increase to as much as 24 percent and during dry, hot periods could drop to below 1 percent. This variation was not so clearly observed in other plant parts.

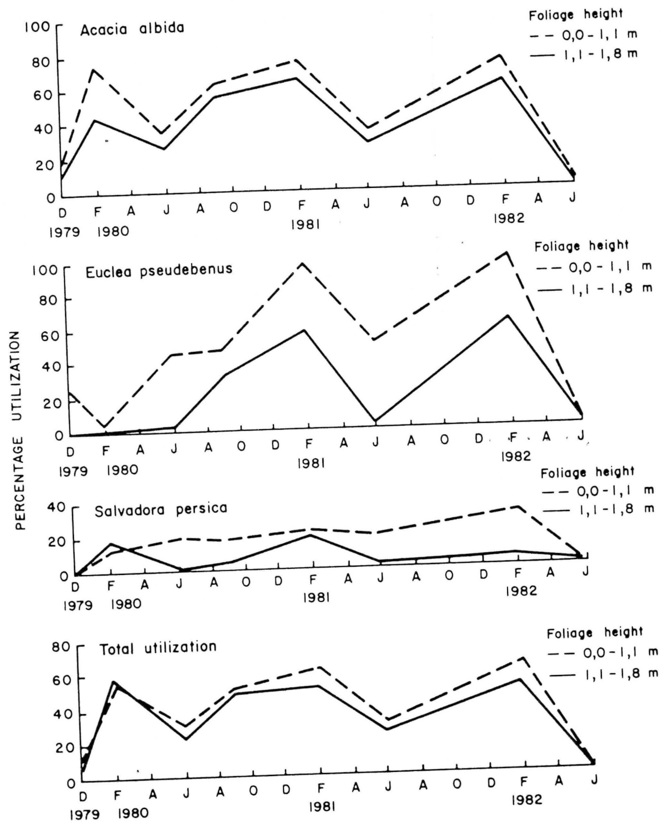

Figure 1. Seasonal utilization of leaf material in oryx grazing area.

POD AND SEED DAMAGE

A sample of A erioloba and A albida pods was collected monthly and examined for damage.

The total pod damage in A albida ranged from 72 to 93 percent and can mainly be attributed to damage by insects of the family Bruchidae. Rodents (Thallomys sp and Rhabdomys sp) also play a role in pod damage. Seed damage is due primarily to insects and varies between 7 and 30 percent.

Pod damage in A erioloba varied between 71 and 90 percent. It was mainly due to insects (Bruchidae), although rodents such as Thallomys and Rhabdomys also played a role. Insect damage counted for 70 to 84 percent of the pods examined. Seed damage, principally due to insects, range from 17 to 44 percent.

Table 4. Maximum and minimum values of the chemical analyses of different organs of five woody species.

	% Moisture		% Organic material		% Digestible organic material		Crude protein		Acid digestible fibre	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
Acacia albida										
Shoots and leaves	74	47	97	91	47	23	18	7	57	30
Leaves	65	50	96	89	49	20	17	6	58	35
Green pods	75	64	89	94	61	43	8	5	40	27
Dry pods	23	0	97	93	69	53	10	4	41	26
Litter	8	1	87	66	45	23	-	-	-	-
Acacia erioloba										
Shoots and leaves	65	38	97	91	52	25	13	5	54	21
Leaves	67	42	97	91	50	29	13	7	61	32
Green pods	66	29	97	93	71	40	9	6	41	24
Dry pods	24	0	98	92	81	39	11	6	39	30
Litter	7	1	83	74	34	13	-	-	-	-
Euclea pseudebenus										
Shoots and leaves	56	41	97	90	32	10	7	3	67	25
Leaves	57	35	95	90	30	10	14	3	61	25
Berries	57	40	97	90	64	23	10	2	66	36
Litter	7	0	90	78	45	13	5	2	63	48
Tamarix usneoides										
Shoots and leaves	64	48	92	83	46	28	10	3	51	35
Litter	10	3	82	66	57	28	-	-	-	-
Salvadora persica										
Shoots and leaves	84	66	87	65	91	66	25	8	33	18
Leaves	82	57	84	57	93	70	21	8	24	12
Berries	76	58	92	79	91	67	-	-	-	-
Litter	11	1	66	52	92	62	-	-	-	-

Pod damage by both insects and rodents varied between 0 and 32 percent for A erioloba and 11 and 42 percent for A albida.

The pod and seed damage influenced the digestibility and germination of the seeds. Rodent damage to pods caused the seeds to fall out and therefore made them more rapidly available for germination. The examination of goat droppings indicated that 100 percent of the A albida and A erioloba seeds present showed no signs of damage, suggesting that all damaged seeds had been digested.

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11. AVAILABILITY OF WATER IN THE LOWER KUISEB AND ITS USE BY LARGE VERTEBRATES

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AVAILABILITY AND QUALITY OF WATER IN THE KUISEB RIVER

Although the Kuiseb is normally dry, the river generally flows each year during the seasonal rains from December to March in the Khomas Hochland catchment area. As the water table falls, the available water is limited to isolated pools, and later even to a few gorras (excavations by game). According to the number of water holes and total water surface in the various sections of the river, the valley and lower lying areas dry up much quicker than those further upstream (Table 1), so that by the end of the dry season no open water surfaces are available within the first 70 km upstream from Gobabeb. Relatively large quantities of water do however occur in the narrow, inhospitable middle section of the ravine throughout the year. According to track surveys made on a regular basis at all open water holes and gorras in the riverbed, it is mainly the mountain zebra, and to a lesser extent the klipspringer and spotted hyena which utilize this water (Table 2). This is in agreement with the curious ability of the mountain zebra and klipspringer to surmount steep, rocky areas, while the rocks occurring scattered in the riverbed (making vehicle transport impossible) provide on ideal hiding-place and shelter for hyenas. Most other game species, especially oryx and springbok, are confined to the easily accessible valley-like areas of the riverbed. Direct observation confirms that inter-species competition amongst the most important herbivores utilizing the Kuiseb is reduced to a large extent, as mountain zebra and klipspringer are limited to the upper well-watered sections of the canyon, while oryx and steenbok occur in the lower lying, well vegetated areas. It is significant that on account of the disturbance caused by the Topnaar settlements, no game was observed in the immediate environment of Homeb, Oswater and Natab.

Chemical analysis revealed that the water of sampled pools and gorras in the Kuiseb River is generally alkaline, with high alkalinity and hardness values. As might be expected, no difference worth mentioning could be indicated in the water quality of the various sections of the canyon (Table 3). The water composition of specific water holes which remained intact long enough to make possible repeated sampling over a period of months, however, shows a definite increase in ion concentration as the dry season progresses (Table 4). Nevertheless the quality of the water remained remarkably high (75 percent of all Kuiseb samples indicate South West Africa grade A standard).