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).

Table 1. Seasonal variation in the relative availability of water in different parts of the Kuiseb River during 1977/78 and 1978-79.

Point of time	Valley (0-40 km) Number	Valley (0-40 km) surface (m^2)	Lower (40-80 km) Number	Lower (40-80 km) surface (m^2)	Middle (80-120 km) Number	Middle (80-120 km) surface (m^2)	Upper (120-160 km) Number	Upper (120-160 km) surface (m^2)
1977 Aug	11	92	62	4025	-	-	99	1694
Sept	12	48	64	562	-	-	74	1016
Oct	10	11	63	473	-	-	45	656
Nov	9	5	39	185	234	6446	39	413
Dec	7	1	23	119	-	-	29	334
1978 Jan	4	1	23	31	163	4182	10	185
Aug	9	64	76	3318	-	-	54	824
Sept	8	29	67	1094	328	13221	44	493
Oct	6	16	53	544	232	11702	33	291
Nov	3	7	32	216	198	7015	19	192
Dec	2	2	20	107	179	5204	15	144
1979 Jan	0	0	18	45	167	3316	14	109

Table 2. Occurrence of game tracks associated with water holes in different parts of the Kuiseb River during 1977-79.

Animal species	Valley section n=56	Lower section n=184	Middle section n=1640	Upper section n=251
Mountain zebra	0	151	1164	238
Baboon	15	39	49	40
Oryx	38	79	81	68
Hyena	12	11	201	13
Jackal	41	22	77	42
Klipspringer	0	37	203	66
Kudu	0	0	4	11
Springbok	21	0	0	4
Ostrich	3	0	0	0
Unidentified	0	0	26	3

Table 3. Chemical properties of water pools in different parts of the Kuiseb River as determined in 1977-78.

Parameter	Valley section n=1	Lower section n=21	Middle section n=14	Upper section n=30
pH	7,5	8,2	8,2	8,2
Conductivity	5993	1390	1425	1123
TDS	3369	967	991	814
Na	1310	220	273	175
K	208	37	31	31
Sulphate	-	76	159	133
Nitrate	-	1,1	0,3	1,0
Nitrite	-	0,1	0,2	0,1
Si	8	11,1	4,9	7,9
F	0,1	0,2	0,3	0,3
Cl	2260	327	296	229
Alkalinity	1380	329	213	252
Total hardness	1475	338	231	268
Ca-hardness	63	153	106	164
Mg-hardness	1412	185	141	102

INFLUENCE ON GAME NUMBERS AND DISTRIBUTION

The most prominent seasonal effect regarding the distribution of game species comprises the regular occurrence of especially oryx in the linear oasis of the Kuiseb River. As the dryness and the average temperature increase towards the end of the year, the oryx numbers in the lower lying areas of the canyon increase on a large scale (see Table 5). A sudden decrease in numbers is however experienced with the first rain of the season, after which only a very few individuals are spotted sporadically in the riverbed. As the oryx in the adjoining gravel plains reveal a relative movement towards the brackish water hole north of Mirabib or even further to the north in the corresponding period, and the remaining individuals concentrate mostly in the immediate region of the easily accessible Zebra Pan (Table 5), this group is probably not part of the Kuiseb population. The river is apparently mainly utilized by oryx of the more southerly dune population during this period in the year.

Approximately 80 percent of all oryx observed entering or leaving the riverbed did so from the southern (dune) side. It is clear that water, despite its poor quality, is the primary attraction for oryx visiting the canyon (see Table 6 and Figure 1).

INFLUENCE ON FORAGE UTILIZATION

The effect of the available water on forage utilization is clearly illustrated by the increased utilization at and in the vicinity of water. Since the beginning of 1981 the pattern has however changed.

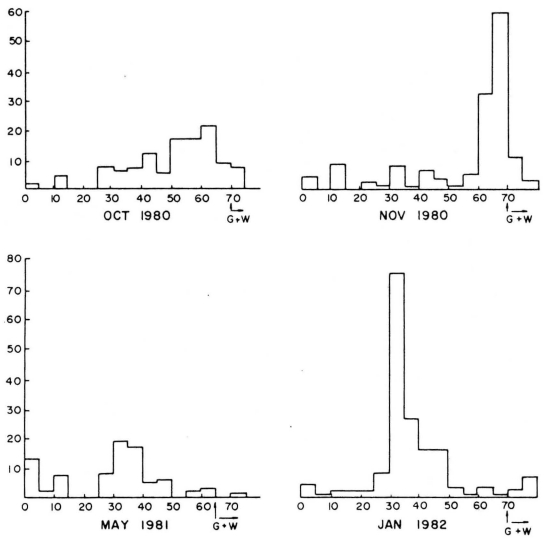

Figure 1. Distribution of oryx in the lower sections of the Kuiseb River.

Table 4. Monthly variation in the chemical composition of specific water holes in the Kuiseb River at the end of the dry season of 1977-78.

	77					78									79
Parameter	Nov	Dec	Jan	Nov	Dec	Jan	Nov	Dec	Jan	Nov	Dec	Jan	Nov	Dec	Jan
pH	7,4	8,2	7,2	7,7	8,3	7,4	8,2	6,8	7,4	7,9	8,9	8,2	8,3	8,0	8,8
Conductivity	730	922	1090	767	751	650	705	783	900	917	865	840	1105	1162	1140
Alkalinity (as CaCO3)	220	244	280	265	276	280	144	239	280	190	291	255	245	276	520
Na	92	136	163	92	74	56	40	78	97	127	102	107	152	174	186
K	30	26	36	36	26	24	17	19	30	27	19	18	25	19	39
Ca	36	37	60	34	37	39	80	86	91	40	78	74	80	74	88
Mg	15	27	34	31	38	32	22	17	24	22	21	17	12	20	41
Cl	115	175	185	95	80	58	83	115	125	163	135	130	210	210	230
SO_4	12	13	16	34	48	22	46	68	76	78	54	54	72	80	15
NO_3	-	7,8	-	2,1	-	-	-	1,8	5,0	-	2,0	3,0	-	3,7	-

INFLUENCE ON THE UTILIZATION OF PODS

Observations show that until the middle of 1981 pods were minimally utilized in the absence of water, but completely utilized at or in the vicinity of water. From the middle of 1981 the utilization of pods in the absence of water increased drastically. The increased uptake of Salvadora apparently compensated for the low moisture content of the pods.

Table 5. Seasonal occurrence of oryx in the Kuiseb River and Zebra Pan area during 1977-78.

Month	Rainfall (mm)	Temperature (°C)	Kuiseb River	Zebra Pan
July 1977	0	26,0	5	40
August	0	27,2	7	47
September	0	25,2	14	57
October	0	28,5	69	65
November	0	28,6	101	69
December	0	30,4	109	92
January 1978	1,0	29,8	118	80
February	49,3	30,1	11	15

Table 6. Seasonal distribution of oryx in the Lower Kuiseb River. Asterisks indicate location of first open water holes and/or gorras.

Distance (km)	1978 Jan	1979 Jan	1979 May-Sept	1979 Nov	1979 Dec	1980 Jan	1980 Feb	1980 March
5	5	1	0	0	8	6	6	2
10	0	8	0	0	0	0	3	6
15	0	0	0	0	7	3	9	3
20	41	0	0	0	1	0	0	0
25	10	0	0	1	0	14	7	2
30	2	0	0	20	26	3	20	16
35	3	6	0	5	46	38	15	6
40	50*	31	0	6	29	3	12	4
45	1	8	0	13	33	8	9	33
50	3	8	17*	48	7	2	2	5
55	1	34	7	30	8	4	2	2
60	0	62*	0	28*	42*	27	9	31
65	0	43	1	7	43	114	156	157
70	0	14	0	16	25	21*	11*	3*
75	0	1	0	6	1	7	14	2