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ECOLOGY OF XEROPHYTIC SAVANNAH

BY

Johan Pfaff Ebersöhn, B.Sc. (Soil Cons.) M.Sc. [Rand]

DECLARATION.

I hereby certify that this dissertation entitled "Ecology of Xerophytic Savannah of Griqualand West' is my own work and has never been submitted for another degree.

J. Ebersöhn
(SIGNATURE.)

Bloemfontein.

Date: 23/12/61.

Ecology has been rather strongly criticized for its emphasis on descriptive study, but surely its ultimate aim is a synthesis that will describe, not only the parts of a complex system but the interaction and balance between them, and the dynamic properties of the system as a whole.

Richard.S.Miller in Ecology, Vol.38 : 353-354.

ECOLOGY OF XEROPHYTIC SAVANNAH

OF GRIQUALAND WEST

with special reference to grazing.

by

Johan Pfaff Ebersöhn, B.Sc.(Soil Cons.), M.Sc.(Rand).

Being a thesis submitted to the University of the Witwatersrand in fulfilment of the regulations governing the degree of Doctor of Philosophy.

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CHAPTER I.

INTRODUCTION.

A. History of development of Griqualand West.

Settlement of the area known as Griqualand West by European farmers occurred after that of the Orange Free State and the Cape Province south of the Orange river. The area's multitude of pastoral problems is in part due to the vegetation being transitional to desert and therefore easily damaged by exploitation. Grave doubts have often been expressed regarding the advisability of opening up xerophytic veld for permanent occupation as farm land.

During the 1836 trek to the north the pioneers preferred the better-watered veld of the eastern Orange Free State and ignored the drier Crown Colony of Griqualand West. Except for occasional springs, pans holding water for a limited period during the rainy season and permanent waterpools in the Vaal and Harts rivers to the east and the Orange river to the south, no surface water existed. The era of the water-drill and windmill had not yet dawned.

The veld was of excellent quality and remained palatable throughout the year, but an obstacle of great magnitude to successful and year-round farming was an acute shortage of phosphorus in the herbage. This element was later shown by Du Toit, Louw and Malan (1940a) to be particularly deficient in autumn, spring and winter and barely sufficient for maintenance of producing stock in summer. Its deficiency caused cattle to crave for bones and carrion. These were often infected by a toxicogeni saprophyte, similar to Bacillus botulinus. Theiler (1920) showed that the eating of infected bones was o of a chain of causes of the disease now commonly called "lamsiekte".

"Lamsiekte" was so bad that intending farmers, when crossing the Harts river to go on the plateau, were advised to leave their cattle behind and to take only small stock, for they would not be

able.../2

able to keep cattle up there alive for long. Farmers in the last century observed, and it was later confirmed by Theiler (1920), that sheep, although also suffering from aphosphorosis, did not exhibit osteophagia. As a result, they did not succumb to "lamsiekte" and could be grazed on the plateau with a greater measure of success than cattle.

The land was sparsely inhabited by scattered nomadic Hottentot tribes and settlements of Griquas who kept some sheep, goats and cattle at the mission stations where the present day towns of Griquatown, Campbell, Boetsap, Likatlong and Kuruman are situated. Except at some of the stronger springs on the plateau and at favoured spots along the Vaal and Harts rivers where some grain was grown, few European farmers settled in the area prior to 1870. Game hunters frequented the area in winter and the plateau also served as drought relief for farmers from the settled districts to the east and south. Large herds of game abounded which were observed always to be moving on to better grazing and fresh water pools or recently burned veld. It was a custom of first the native people and later of hunters to burn the veld over large areas. This ensured the availability of a supply of game for as long as green grass following the burn lasted.

Droughts were common even in those early days, as Burchell (1822) so aptly describes on page 235 in the account of his travels: "No grass, nor verdure covered the stony ground; only a few scattered bushes contributed scarcely a tint of green to vary the barren brown colour which distinguished the mountains." On page 351 he mentions severe duststorms whereby "astonishing quantities of the finer particles were carried up by the wind and filled the whole atmosphere." But droughts were invariably followed by rain and at the entry for 13th November 1811 it is remarked that, "we travelled over a plain of boundless extent, producing much grass in some places and a few bushes of Tarchonanthus."

The fact that bushes were present in abundance in the early

days.../3

days and that they are not a product of present-day farming is confirmed by Dr. Andrew Smith (1835) who recorded on the 5th of March that, "we passed over country with an abundance of trees and bushes."

Livingstone (1857) remarked on the astonishing quantity of grass which grew in the region and writes, "hundreds of miles of grass covered the plains", and "the vegetation consists of fine grass growing in tufts among low bushes."

With the discovery of diamonds at Kimberley and along the Vaal river in 1869, a new era dawned on the region. Wood as fuel for the mines was in high demand and wood-cutting, first around Kimberley and in the vicinity of the river diggings and later further afield to the Harts river and on the plateau, became a profitable undertaking. This phase lasted until about 1910 and gradually made way for other enterprizes. Up to the present day some Griquas still make a living from wood-cutting, carting it to Kimberley where it is sold as firewood. They return with building or fencing material for traders in the plateau area.

However, from 1870 onwards the Cape Government gave quit-rent titles to farmers and increasing numbers of settlers moved into the area, most of them combining wood-cutting with stock farming, mainly sheep. When carting wood to Kimberley and the Vaal river, all the menfolk would go with the waggons and on their return home it often happened that some of their stock would be missing, with all traces and tracks lost. Stock were kraaled at night and herded in the daytime to guard them against thieves and wild animals preying on them. They were watered at the springs or "fontein" of which placenames such as Blikfontein, Ariesfontein, Ruigtefontein, Koopmansfontein and so forth still bear testimony. At the stronger wells and springs bucket pumps and windlasses served to lift the water to the surface and into drinking troughs. Aloes in the veld, now largely destroyed by overgrazing and baboons, also supplied moisture for stock and enabled animals to go for months on end without drinking water.

Stock.../4

Stock diseases, among others "lamsiekte", anthrax and lung disease, along with wireworm in sheep and hydrocyanic poisoning and "brandsiekte" were common. A popular belief in those days were that the best way to rid sheep of internal parasites was to let them graze on the burnt-over veld so that the sheep could ingest some of the ashes along with green grass, this combination being reputed to have had appreciable medicinal effect.

Produce from the farms was disposed of at Kimberley and along the Vaal river where the diamond diggings and mines provided a ready market, and also to pedlars moving from farm to farm and to trading stores at Danielskuil, Koopmansfontein and further afield. Livestock buyers from the Rand and Kimberley also frequented the area; some farmers even drove their stock as far afield as Vryburg and even to Johannesburg where regular stock fairs were held.

The first fence to be put up was probably along the southern boundary of the area in 1897. This was known as the Runderpest Fence, put up by the Government for the purpose of preventing stock moving south into the Colony and spreading the disease into those parts. Some portions of the fence may still be seen to this day.

Veld burning was common and occurred throughout the year whenever grass was dry enough to burn. Widespread veld fires, many miles broad, came either from the north or the northwest and were carried before the wind for hundreds of miles, dying down at night and flaming up again in the late morning. Occasionally farmers burnt the tall grass, which would reach to the saddleflaps on their horses. In this way the grass was forced to sprout again, thereby providing green herbage out of season.

The runderpest of 1897 is claimed to have wiped out majority of cattle, including the draught oxen of the wood-ride it even led to a minor war, because the native tribes were not willing to have their infected stock shot by the police. Because of the decimation of cattle through runderpest, merino sheep farming began to assume great prominence. It was not until Hutchinson and Spruell,

Government.../5

Government Veterinary Surgeons had conducted some experiments at Koopmansfontein from 1905 to 1907,using among others burnt bone and steamed bonemeal, that a prophylactic for "lamsiekte" was found. Now cattle farming again became the main occupation.

Below the Ghaap plateau ring fencing of farms was started early in the 1880s, but it was not until 1910, when the first holes for water were sunk and windmills were put up that boundary fencing on the plateau was commenced. The advent of the waterdrill and windmill heralded a new era. Whereas up to that time, stock were concentrated round the wells and only farms with perennial springs could be farmed, "dry" farms could now be exploited. Cattle farming benefited from the fencing and the stock-watering facilities provided. Fencing indirectly caused the wood-cutter and hunter to sell out to others; conditions were becoming less favourable for their stock and trade. In addition it is claimed that fencing made dairy ranching, sponsored by the Cape Government to supply butter and cheese to the diggings, profitable and sheep farming lucrative.

After the first world war a large-scale influx of settlers from the Orange Free State followed and with their settling more emphasis was placed on sheep farming. These settlers are reputed to have believed that sheep ate the shrubs in preference to grasses and did better on them. Overgrazing became prevalent and with land cheap at one Rand[£] a morgen[Ω] no thought was given to veld management.

In 1919 Sir Arnold Theiler (1920) and his colleagues established the cause of "lamsiekte" and confirmed the earlier recommendations as to the feeding of boneflour to stock and the removal of carrion from the veld as preventive measures. The chronic deficiency of phosphorus in the herbage could be met by bonemeal supplementation and cattle were less prone to pick up bones and carrion. This discovery gave cattle farming a long needed boost and led to it becoming firmly established.

Ring and even camp fencing was now in full swing. Severe

£ One morgen = 2.14 acres.

Ω One Rand = 10 shillings sterling.

Geigeria.../6

Geigeria-poisoning outbreaks in 1926/27 and again in 1929/30 decimated a large part of the sheep flocks and the 1933 drought was the cause of hundreds of cattle dying from poverty.

Vermin-proof fencing was commenced in 1929 and was accompanied by a pronounced change-over from sheep to cattle and from merino to mutton sheep types. The railway line to the asbestos and manganese mines at Postmasburg had by then passed beyond Koopmansfontein, and cream could be sent to the factory at Kimberley.

By 1930, most of the land had been taken up by farmers, to the west as far as the Langeberge and to the north as far as the Kuruman river. On large blocks of farms however, water could not be found and these remained unoccupied. They were only taken up in recent years when deep drilling for water became possible.

The 1931/33 drought hit farmers very hard and is remembered, along with the 1897 rinderpest epidemic the 1929 Geigeria-poisoning epidemic and the 1949 drought, as one of the worst years on record. When the three-year long drought broke in 1934 the veld was in a depleted condition and the carrying capacity much reduced. The veld took years to recover. Some old farmers maintain that the veld has never recovered yet and that most of the present day ills on the veld could be ascribed to the great drought of 1933.

As illustrative of the numbers of livestock kept in the area, Table I. covering more than a third of a century, is given.

TABLE I.../7

TABLE I.

LIVESTOCK NUMBERS IN TWO GRIQUALAND WEST DISTRICTS, IN THOUSANDS.(r)

	Barkly West.			Herbert.		
Census Year.	Cattle	Sheep & Goats	Ratio.	Cattle	Sheep & Goats	Ratio.
1918	19	302	1:16	14	247	1:18
1921	36	368	1:10	19	267	1:14
1924	28	327	1:12	20	248	1:12
1927	32	534	1:17	16	287	1:18
1929	48	424	1:9	15	361	1:24
1934	55	360	1:7	8	266	1:33
1936	46	308	1:7	14	381	1:27
1939	65	239	1:4	23	359	1:16
1946(s)	92	184	1:2	22	274	1:12
1949(s)	68	166	1:2	24	341	1:14
1952	59	122	1:2	21	349	1:17
1954	56	124	1:2	23	314	1:14

(r) 1918 to 1954 Agricultural Censusses of the Union of South Africa.

(s) District of Barkly West reduced.

The census figures confirm the views of old farmers that there has been a pronounced swingover since 1929/34 to the keeping of more cattle and fewer small stock and that since 1946 a fairly stable ratio of large to small stock has been maintained. Saturation point in livestock numbers was probably reached by 1939, and it is thought that neither the numbers of livestock nor the ratio of large to small stock will vary much in the future.

The lower ratio of large to small stock in the Herbert as compared with the Barkly West district is in part the result of drier conditions in the former district which render the area less suitable for large stock. The large numbers of sheep is a cause for alarm,

because.../8

because with such a wide ratio of cattle to small stock it is only with difficulty, if at all, that stable veld can be established. Geigeria thrives under the existing unstable vegetational conditions. Thus farmers continue to face the danger of severe outbreaks of Geigeria-poisoning at times when the quantities of herbage acceptable to sheep are minimal. This has been shown again and again during the last two decades by the occurrence of sporadical "vermoersiekte" outbreaks in the Herbert and Hay districts.

B..../9

B. Deterioration of veld and "vermeerbos" and "bitterbos" problems.

The picture of what the vegetation was like on the Ghaap plateau in the early days before settlement on a large scale took place had to be reconstructed from the following sources: (i) The memories of early settlers, (ii) Travel accounts of Burchell (1822), Livingstone (1857) and Smith (1835) into the interior of South Africa, (iii) The behaviour of veld under grazing, and (iv) The judging of successional trends in the vegetation as obtained from total and partial protection from grazing.

It was repeatedly emphasized by Claasen (1961), Ford (1961) and Paton (1961) that the grasses grew out so tall that their inflorescences would reach to the saddle bottoms of a rider on horseback. From the same sources it was learned that the veld was too wild for successful sheep farming, the only feasible enterprize under "lamsiekte" conditions.

The practice of taming or "maktrap", whereby portions of the veld were burnt and severely grazed by cattle had to be resorted to. This rendered the subsequent growth of herbage more acceptable to sheep. When cattle numbers increased and cattle ranching assumed prominence in the late nineteen-twenties, the process had resulted in a reversal of the succession which had regressed to the seral stage. It may safely be assumed that cattle never had the full benefit of Griqualand West veld when still in the tall-grass, open savanah stage.

The recollections of the older inhabitants leave little doubt that the veld was an open savanah with Tarchonanthus and Olea, the trees and shrubs being shorter in stature on soils with little depth and increasing in size on the deeper soils along watercourses, drainage lines and on crumbly limestone substrata.

It appears most likely that taming of the veld was directed mainly against the taller growing, hardier and less palatable grasses like Cymbopogon plurinodis and Aristida vestita on lime veld, and against Sporobolus acinifolius and Heteropogon contortus on dolomite-

veld.../10

veld. The palatable species like Fingerhuthia africana. Themeda triandra and Cenchrus ciliaris, among others, bore the brunt of the taming and suffered most. Seral species like Eragrostis lehmanniana benefited and pioneers like Aristida curvata, Enneapogon brachystachyus, Tragus racemosus and possibly Oropetium capense, along with the noxious Geigeria africana and the woody Chrysocoma tenuifolia, increased in abundance.

Shaw (1875) commented as follows on this process of degeneration of the veld: "The hardy plants of the Karoo commenced to travel northwards and added their energies to the extorpating of the indigenous and proper flora of the region. Species like Chrysocoma, Pentzia and so on, largely developed in the Karoo, came in; moreover, being of a bitter and nauseous character, they enjoyed immunity... This Karoo veld is extending even into the Vaal region, and is a common bush in the lately occupied parts of the diamond fields, the Crown Colony of Griqualand West. It is, wherever it goes, a sure index of a changing climate and persistent moisture weakens it."

Steyn (1943) supports this view when he states: "It is essential that farmers should realize that our pastures have already been so seriously damaged by overgrazing, veld burning and incorrect grazing, that menaces to the livestock industry such as "lamsiekte", internal parasites and plant poisoning are continually increasing while the milk yield, vigour, wool production and breeding capacity of stock are continually declining."

Stoddart (1945) stresses the fact that "too many animals bring about deterioration of the vegetation resulting in species poorer in both nutritional value and soil protection value. Usually there also is a reduction in the amount of vegetation produced."

Van der Schÿff (1948) is in full agreement about the course of events and their effects as set out above. He found "vermeerbos" admirably adapted to invade or multiply in weakened or trampled-out grassveld. He points out certain characteristics of the plant which he thinks will favour its survival, namely, the burrowing of its seed

into.../11

into the ground, germination mainly in the lower temperatures of spring and autumn, as well as winter survival of individuals germinating in autumn. But he emphasises that these characteristics will only operate significantly where the veld has been impoverished and where there is little competition from other plants.

Phillips (1956) claims that the area is in imminent danger of increasing dessication as the outcome of mismanagement of livestock.

Costello (1957) is emphatic on the point of imbalance between species, when he asserts that,"the range, due to the great chance of it becoming overgrazed and eroded, is probably more subject to imbalance than any other natural community."

The allegation that the damage was mainly to the taller grasses is in line with what Dix (1959) found in Wisconsin, where the predominantly upright growth habit of the tall-grass prairie species rendered them highly susceptible to grazing by livestock, the more xeric species being less susceptible to grazing injury than the more mesic ones.

It must be borne in mind that Griqualand West was settled, with few exceptions, by relatively poor farmers with limited resources and only a few head of stock. With small numbers of livestock involved, summer grazing was excellent and winter grazing and browsing provided maintenance. Virtually no fences existed and the early settlers were known to trek many miles with their stock following out-of-season rains and burns.

The few head of stock had the run of the country and grazed the most palatable grasses only. This resulted in them being weakened and decreasing with increasing stock numbers. Meanwhile the area was becoming fully settled, but the early settlers did not mind at all. The country was open and there was always adequate grazing to spare. In spring and autumn the ungrazed grasses would be burned over, and in the following winter or summer the grazing would be fine again. But the livestock saturation point of the veld was slowly but inevitably being reached. From then on farmers were confined

to.../12

to their own properties and no longer could they follow the rains with their stock or burn indiscriminately or obtain unlimited grazing from unoccupied crown land.

On what was tamed for sheep, the cattle farming pattern unfolded. Sparrman (1786) and Humphrey and Mehrhoff (1958) agree that the pastures, subjected to the changed conditions, were producing much less forage than they once did.

But in most cases the taming of veld had gone too far. The low production and poor quality of the herbage was being attributed to a low and erratic rainfall. The Joint Committee (Anonymous, 1933) however, summed up the poor condition of the veld very aptly by stating, "it appears to be the inevitable and logical results of consistent neglect and bad management for many years."

On most farms, Chrysocoma tenuifolia, in particular on gravelly soils and in well-drained situations, had taken a firm hold and Geigeria africana repeatedly was the cause of heavy losses. In spite of severe disturbance of the vegetation, some species managed to persist. Shantz and Turner (1958) also found that, "No matter how severe the disturbance, it seems an axiom that some kind of vegetation will persist or become adjusted to the new conditions, even in semi-desert regions and even when soil deterioration is extreme."

Parker (1952) summed up the process of veld retrogression when he affirmed that, "undesirable range plants invade or increase on range areas; usually the desirable species have been killed or weakened by too frequent and too close grazing."

The abundance of rock outcrops and the general stoniness of the veld of Griqualand West may however have been an agency checking the rate of depletion. Lamb and Chapham (1943) confirm this as a possibility, in that they found a high stone cover of 65 per cent, "to increase soil temperature and to maintain a higher soil moisture content." Burns, Kulkarni and Godbole (1931) also affirm the fact that, "stones which occur, particularly on the hilly areas, give a certain amount of protection to the grasses growing amongst them and

also.../13

also act as a kind of mulch."

The fact that, immediately following rains, and in good rainfall years, pioneer and seral grasses grew in profusion and that therefore an abundance of herbage, highly acceptable to sheep was available, is probably the reason why Geigeria-poisoning did not occur sporadically every season or right throughout whole seasons. But during prolonged dry periods, these short-lived plants soon withered away, and in the absence or low incidence of perennial tuft grasses which are able to go on producing herbage long after pioneer plants and seral grasses have disappeared, Geigeria-poisoning made its appearance. Its disastrous effects increased whenever droughts occurred and where leafy, tuft grasses had been killed out by overgrazing.

With Chrysocoma tenuifolia the process of invasion and increase appear to be slightly different. Under severe grazing and with a 70 per cent of surface rock, trampling of the soil became an important factor conducive to its spread. As the thin layer of soil, never of great depth, wore thinner and was blown in under the shrubs, C. tenuifolia took hold of the denuded areas.

It will presently be shown that the taming of the veld, or the causation of retrogression of the veld to a grazing sub-climax, was in itself not a condemnable practice. Excellent production must have resulted initially, but the objection to taming of veld was not one of principle, but one of degree. The process had been taken too far, in most cases to large bare patches in the veld where Chrysocoma and Geigeria found easy entry and began to increase once they had gained a foothold.

Acocks (1953) claims that the change due to taming, although advantageous to sheep farming, was highly undesirable because of the accompanying increase in poisonous plants and a rapid advancement of the Karoo in the form of "thickets of less valuable shrubs and trees like Rhus ciliata, Acacia mollifera var. detinens and A. heteracantha, while valuable fodder shrubs like Tarchonanthus minor are suffering the usual fate of useful plants - being killed out."

Characteristics.../14

Characteristics of good veld are, in terms of botanical composition, a good cover consisting chiefly of Eragrostis lehmanniana, but with a high proportion of palatable, leafy, tufted, perennial grasses, and a low incidence of Chrysocoma tenuifolia and Geigeria africana. A high incidence of Tarchonanthus minor and few Rhus ciliata also goes to make good veld.

Burns (1939) defines good veld as that in which, "the gradual elimination of unpalatable and non-nutritious species and their replacement by palatable and nutritious kinds is taking place." He mentions a further requirement in that there ought to be an increase in the quantity of feed per acre.

Parker (1952) regards well managed veld as, "one which has been grazed by livestock on a sustained yield basis and which is in an optimum state of soil stability and quality and has the highest possible state of development of vegetation under the prevailing climate."

In terms of animal production, good sweet veld is one which, in the case of steers, gives rapid growth in summer which gradually slows down in autumn; it must give maintenance in winter and only slight liveweight loss in spring. With sheep, good veld is expected to give rapid growth in summer, slower growth in autumn and winter, and maintenance, or only slight liveweight loss in spring.

C.../15

C. Establishment of the Koopmansfontein Pasture Research Station.

The Koopmansfontein Pasture Research Station came into being in 1940 as a sequel to the urgent requests from farmers asking for an elucidation of the "vermoersiekte" problem. Thousands of sheep were dying from poisoning after eating Geigeria and there was nothing farmers could do to counteract it. Surprisingly, no pressure was brought to bear on the Government regarding Chrysocoma and its encroachment, although it probably constitutes a greater threat to farming than Geigeria. This may be explained by the fact that losses from Geigeria-poisoning were more obvious and spectacular, while Chrysocoma has debilitating effects likely to prove more serious in the long run.

Farmers, through their farmer associations, requested the Government to establish an experimental station where the Geigeria-problem could be investigated. They held that the research should focus on animal-plant ecological aspects, in contrast to the chemical and toxicological aspects which had, up to then, received sporadic attention through the work of Du Toit (1928) and Rimington and Roets (1936).

More now, was a fresh approach. Veld reclamation was to pave the way to improve the herbage and to lower the incidence of Geigeria, thus lessening the probability that Geigeria-poisoning would occur. The Department of Agriculture, acting on this presumption, acquired a farm known to be heavily infested with Geigeria and with Geigeria-poisoning a common occurrence. Various veld management experiments were planned and put into practice on the research station from 1944 onwards.

The object of these experiments was to find out, in terms of cattle and sheep, separately and jointly,

(i) how much stock the veld could carry,

(ii) whether the various systems of management would influence the carrying capacity and stability of veld,

(iii) whether there would be botanical changes in the veld, and

(iv).../16

(iv) whether the incidence of Geigeria-poisoning would diminish under the various ways in which the veld is managed.

A point of view widely held by pasture research workers was that, once the veld could be improved to something resembling its original condition, Geigeria-poisoning would be a thing of the past.

Crocker (1952), in referring to grazing effect experiments, warns that unless such investigations are supported by more active programmes, they are too negative to be very productive. He regards it as extremely doubtful if they are ever worth undertaking unless situations to which they refer are clearly understood.

In Table II details are given of grazing effect experiments conducted at the Koopmansfontein Pasture Research Station from 1944 to 1957.

TABLE II.../17

TABLE II.

VELD MANAGEMENT EXPERIMENTS AT KOOPMANSFONTEIN.

Date Commenced	Expt. No.	Rate of Grazing.	System	C/S Ratio	Veld Sub-type	Size of Expt.	Date Concluded.
31.10.44	6 L	1B/8m.	III	-	Lime.	24m.	15.7.53.
"	6 D	"	"	-	Dolomite.	"	"
"	7 L	"	IV	-	Lime.	"	"
"	7 D	"	"	-	Dolomite.	"	"
"	8 L	"	V	-	Lime.	48m.	"
"	8 D	"	"	-	Dolomite.	"	"
"	9 L	1B&8S/16m.	VI	1/8	Lime.	"	"
5. 2.46	1 L	1S/m.	I	-	"	10m.	"
"	2 L	"	II	-	"	"	"
"	3 L	"	III	-	"	"	"
"	3 D	"	"	-	Dolomite.	12m.	"
"	4 D	"	IV	-	"	"	"
"	5 D	"	V	-	"	24m.	6.7.57.
8. 6.48.	10 L	1B/12m.	III	-	Lime.	36m.	"
"	10 D	"	"	-	Dolomite.	"	"
"	11 L	1B/6m.	"	-	Lime.	18m.	"
"	11 D	"	"	-	Dolomite.	"	"
"	14 L	1B&4S/12m.	VI	1/4	Lime.	48m.	"
"	14 D	"	"	"	Dolomite.	"	"
"	19 L	1B&16S/24m.	"	1/16	Lime.	"	"
"	19 D	"	"	"	Dolomite.	"	"
28. 2.50.	1 D	1S/m.	I	-	"	10m.	"
"	2 D	"	II	-	"	"	"
"	4 L	"	IV	-	Lime.	12m.	"
"	5 L	"	V	-	"	24m.	"
"	12 L	3S/2m.	IV	-	"	12m.	"
"	12 D	"	"	-	Dolomite.	12m.	"
"	13 L	1B&4S/9m.	VI	1/4	Lime.	36m.	"
"	13 D	"	"	"	Dolomite.	"	"
"	15 L	1B&4S/15m.	"	"	Lime.	60m.	"
"	15 D	"	VI	"	Dolomite.	"	"
"	9 L	1B&8S/16m.	"	1/8	"	48m.	"
2. 8.52.	16 L	1B&1S/12m.	VII	1/1	Lime.	"	"
"	17 L	"	IV	"	"	"	"
"	18 L	2B&1S/22m.	VII	2/1	"	88m.	"

The ratio of cattle to sheep in Expts.19 L and 19 D were changed from 1/16 to 1/4 on 1.7.52

The system of Expts. 13 L and 13 D, 14 L and 14 D, and 15 L and 15 D were changed from system VI to system VII on 1.7.52.

B = Beast; S = Sheep; m = morgen; one morgen = 2.14 acres

D.../18

D. Physiographic features of the area.

Topography: Wellington (1946), basing his physiographic delimitation primarily on altitude and surface form and secondarily on drainage, aspect and geology, classifies Griqualand West as South-African Pro-Karoo Highveld. "In the west the area is bounded by the Asbestos and Kuruman hills which rises 500 feet above the surrounding country. In the east and south the area is bordered by the 500 feet high escarpment of the Campbell Rand; in the north it is differentiated chiefly by the climatic effects on surface character.... great areas of the plateau surface being covered with lime accretion resulting from the low rainfall and high evaporation."

The surface relief varies from almost flat to gently undulating, broken by isolated"koppies" The eastern edge of the plateau forms an escarpment. The Harts river, a tributary of the Vaal, forms with the Bootsap river, the main drainage line towards the east. Towards the far west the Mashowing, Mathlarin and Kuruman rivers drain the area. The south and south-east are drained by the Klein Rietriver, Sandriver and Gamagara rivers.

The monotony is only rarely broken by pans and depressions, from a few inches to a couple of feet deep and from a few yards to a mile or more in diameter. Occasional watercourses occur. They are usually not more than a few feet lower than the surrounding country, except near the escarpment where they deepen.

As to the origin of these pans, Geyser (1950) advanced the theory that they "are the result of some or other disruption of the normal drainage, the disruption usually being the result of stream capturing." He regards pans as temporary land forms which occur in a transitional period between one drainage system and another. The pans on the Ghaap plateau lends support to this theory in that they still, in times of abnormally heavy rains, form shallow drainage lines, one overflowing into another.

The research station is centrally situated on this plateau at 4,500 feet above sea level at 28°12' south latitude and 24°4' east

longitude.../19

longitude.

Rainfall and Temperatures: Details of rainfall and temperature are given in Table III.

TABLE III.

RAINFALL (MM.) AND TEMPERATURE (°C) AT KOOPMANSFONTEIN : 1941 - 58.

Months.	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Rainfall:												
Lowest.	0	0	0	0	0	0	8	6	33	0	0	0
Mean.	6	8	15	4	20	46	61	66	89	41	15	17
Highest.	26	116	52	87	66	123	214	158	235	148	56	124
Temperature:												
Abs. maximum.	25	29	32	35	36	38	38	35	35	32	28	25
Mean maximum.	17	20	24	27	29	30	31	29	27	24	21	17
Mean minimum.	-1	2	5	9	12	14	15	15	13	9	4	1
Abs. minimum.	-10	-8	-5	-3	2	6	2	5	4	-3	-6	-9

Temperatures are given as read in a standard Stevenson screen.

For the period 1941 to 1958 the annual rainfall varied between 151 and 588 m.m., averaging 370 m.m. per year. Ebersöhn (1959), in an analysis of rainfall recorded at the research station, showed that 77 per cent of the rain occurred from December to April, eight per cent from May to July and 15 per cent from August to November.

With wide fluctuations in day and night temperatures the climate is typically continental, and five months only, coinciding with the rainy season, is frost free. "Days range from 'Mild' in winter to 'Warm' in spring and autumn to 'Hot' in summer. Nights range from 'Mild' in summer to 'Cool' in spring and autumn to 'Cold' in winter"(Ebersöhn, 1956).

Köppen, as quoted by Schulze (1947), in basing his classification on temperature and rainfall averages, includes Griqualand West in his B Sh w' region, signifying arid-steppe, hot and dry, and with the dry season in winter. Thornthwaite, also quoted by Schulze

(loc.cit.).../20

(loc. cit.) basing his classification upon the precipitation, evaporation and temperature efficiency indices, delimits the area as D B'd, i.e. semi-arid, meso-thermal and moisture deficient in all seasons.

Bannerji (1952) describes savannah as having a "pronounced period of drought for more than six months after the rainy season in summer, plus high temperatures and high evaporation", while Schimper (1903) refers to savannah as "xerophilous grassland containing isolated trees." Phillips (1956) regards the climate as sub-desert, "the hazards of which exist in the uncertain length of the dry season (7-10 months) and in the actual break, intensity, sequence and proportionate distribution of the rains."

Soils: The soils are classified by Van der Merwe (1941) as Kalahari Desert soils belonging to the Kalahari Sand on Limestone Sub-Group. He says: "They are of windblown origin, the Kalahari Sand being the source of the soil material. This aeolian material was deposited on the geological strata. Well developed normal soils consist of a light brown to reddish brown to brick red sand, fairly evengrained, coherent friable, well fixed by roots of vegetation, deficient in humus and varying in thickness from a few inches to about eight feet with little or no change in texture and structure and in many instances in colour."

"Underlying the sandy horizon of the well developed soil, with a sharp transition, is found a dirty white to white limestone layer which varies considerably in texture."

"When exposed on the surface or concealed by a thin layer of sand, the surface layer of this "B" horizon consists of boulder limestone, extremely hard, breaking up into big blocks or boulders. This layer is always well fissured through which certain vegetation (Vaalbush) manages to send its roots, probably down to the water table."

"The thickness of boulder limestone varies from 12 to 24", underlain by a softer layer consisting of nodular and powdery $CaCO_3$

mixed.../2

mixed, which ranges in thickness from 12" to many feet, passing gradually into a mechanically disintegrated rock mixed with limestone." He makes the deduction that the underlying geological formation does not contribute any soil material as such to build up the profile, except the lime which is dissolved by the soil moisture. The limestone horizon is formed by the evaporation of water charged with the dissolved $CaCO_3$, rising to the surface by capillary action. He also contends that the limestone layer is built up in the superficial sand deposit, from below.

Vegetation: Shantz and Marbut (1923) consider the Ghaap plateau as part of the Acacia Tall-Grass Savannah formation. Adamson (1938) classified the vegetation as savannah, with trees or bushes, usually deciduous, scattered in a grass undergrowth. Nobbs (1938) regarded the area as "the utmost meeting point of kalahari grass, xerophytic bushveld and Karoo."

Acocks (1953) calls the variation of the Vryburg Shrub Bushveld occurring at the research station, "dense Tarchonanthus bushveld, composed of shrubs and sometimes small trees in a mixed grassveld.... On the low dykes of more crumbly tufa than the generally slabby tufa of the flats and at the edges of the numerous and remarkably large and small pans and shallow drainage channels, Themeda has persisted better than elsewhere..... This form of the Vryburg Shrub Bushveld is the sweetest, such grasses as Digitaria, Chrysopogon and Eustachys finding a safe refuge in the crevices between the slabs of tufa. On the other hand, Geigeria passerinoides syn. africana is here most abundant, a stunted form which is reputed to be the most dangerous to sheep. Here and there one gets the impression that the turfy soil may once have formed a continuous cover over the tufa, but if so, it has disappeared with surprising completeness."

Two main sub-types of veld are recognized as composing Tarchonanthus bushveld, namely Limeveld and Dolomiteveld.

(i) Limeveld:

The shrub on this type consists of bushes three to ten feet

in.../22

in height, singly or in clumps, branching freely from the ground surface and seldom with a clean trunk except in the case of Olea africana. The dominant shrubs are Tarchonanthus minor, Tarchonanthus camphoratus var. litakunensis, Rhus lancea and Grewia cana. Associated with these are Euclea ovata, Ziziphus mucronata, an occasional Rhus pyroides, Maytenus cymosus, Ehretia rigida, Royena hirsuta and Rhus ciliata. The shrubs have a typical peppercorn appearance and the canopy cover afforded varies between fifteen and forty per cent.

The grasses on limeveld are characteristically tufted with a purplish to reddish tinge when matured. Themeda triandra, Chrysopogon montanus, Cymbopogon plurinodis, Fingerhuthia africana, Sporobolus fimbriatus and Eustachys paspaloides are the principal perennial species.

Karroid suffrutices are represented by Sutera atropurpurea, Monechma divaricatum, Indigofera patens, Blepharis marginatus, Barleria bechuanensis, Aster muricatus, Pterothrix spinescens, Helichrysum lucilloides, Nemax microphylla, Solanum nigricans and Hypertelis verrucosa.

Steadily gaining ground, and at times poisonous to stock, are Geigeria africana, Chrysocoma tenuifolia, Ornithoglossum glaucum and Dipcadi spp.

Numerous sandy depressions or "pannetjies" occur scattered throughout the limeveld. Shrubs are seldom present in these, but Panicum coloratum, Sporobolus fimbriatus and Themeda triandra are common in them.

Trampling by stock has the effect that the permanent constituents give way to Eragrostis lehmanniana. Aristida curvata, Enneapogon brachystachyus and Tragus racemosus. Geigeria africana seldom occurs in these trampled areas in the "pannetjies", contrasted with trampled areas elsewhere, where Geigeria infests readily.

(ii) Dolomiteveld.

The shrubs on this veld type are larger, up to fifteen

feet.../23

feet in height and closer together than on limeveld; Acacia mellifera var. detinens, Tarchonanthus camphoratus var. litakunensis, T. minor, Rhus lancea, R. ciliata and Grewia cana predominate. Occasionally Olea africana, Ehretia rigida, Ziziphus mucronata, Royena pallens and Maytenus cymosus are associated with them.

The dominant grasses are Heteropogon contortus, Digitaria eriantha, Aristida vestita, Cenchrus ciliaris and Enneapogon scoparius. Today Cenchrus ciliaris occurs mainly in well protected sites among rocks, under thorn bushes and on ledges where stock have no easy access. Themeda triandra, Cymbopogon plurinodis, Chrysopogon montanus, Sporobolus fimbriatus and Eustachys paspaloides are less common on dolomitoveld.

Badly trampled areas lose the perennial tufted grass species and revert to Aristida curvata, Eragrostis denudata, E. lehmanniana and Chrysocoma tenuifolia. Geigeria africana invades dolomitoveld wherever limestone outcrops occur. In some cases Pentzia globosa invades both lime- and dolomitoveld.

No distinct difference is evident between the plant succession on these two veld sub-types and the illustration in Table IV is a tentative attempt at indicating the trends in the succession of the more common species.

TABLE IV.../24

TABLE IV.

PLANT SUCCESSION IN TARCHONANTHUS BUSHVELD AT KOOPMANSFONTEIN.

LIMEVELD.	DOLOMITEVELD.
CLIMAX SHRUBS.	
Olea africana.	
Tarchonanthus camphoratus var. litakunensis.	
Tarchonanthus minor.	Acacia mellifera var. detinens.
Grewia oana.	Rhus lancea.
	Rhus pyroides.
	Royena hirsuta.
	Rhus ciliata.
CLIMAX GRASSES.	
Aristida vestita.	Sporobolus acinifolius.
Cymbopogon plurinodis.	Heteropogon contortus.
	Themeda triandra.
	Chrysopogon montanus.
Sporobolus fimbriatus.	Digitaria eriantha.
Fingerhuthia africana.	Cenchrus ciliaris.
Eustachus paspaloides	Enneapogon scoparius.
SUB-CLIMAX SPECIES.	
Eragrostis lehmanniana.	
Tragus koelerioides.	Eragrostis denudata.
Eragrostis obtusa.	Pogonarthria squarrosa.
PIONEER SPECIES.	
Aristida curvata.	
Oropetium capense.	
Enneapogon brachystachyus.	
Tragus racemosus.	
Aster muricatus.	
Chrysocoma tenuifolia.	
Geigeria africana.	

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. In a vegetation survey undertaken according to the wheel-point method of Tidmarsh and Havenga (1955) of veld in good condition and of badly damaged veld, the following composition in terms of basal area cover was found.

TABLE V.../26

TABLE V.

PERCENTAGE BASAL AREA COVER OF LOWER-STOREY VEGETATION ON LIME AND DOLOMITEVELD AT KOOPMANSFONTEIN.

Species.	Limeveld.		Dolomiteveld.	
	Well-managed (r):	Mismanaged (x):	Well-managed (y):	Mismanaged (z)
Eragrostis lehmanniana.	3.80	1.15	7.20	3.67
Oropetium capense.	1.50	0.95	2.07	2.20
Chrysopogon montanus.	1.33	0.10	1.83	0.27
Cymbopogon plurinodis.	0.87	0.15	0.37	0.03
Enneapogon brachystachyus.	0.83	0.90	-	-
Digitaria eriantha.	0.87	0.10	1.23	0.69
Themeda triandra.	0.80	-	1.00	0.03
Cyperus esculentus.	0.45	0.45	-	-
Sporobolus fimbriatus.	0.37	-	0.10	0.13
Goigeria africana.	0.37	-	0.03	0.03
Aristida curvata.	0.30	0.30	0.20	0.44
Brachiaria eruciformis.	0.30	-	-	-
Monechma divaricatum.	0.17	-	-	-
Tragus koelerioides.	0.13	-	0.03	-
Cynodon incompletus.	0.10	-	-	-
Eustachys paspaloides.	0.07	-	-	-
Eragrostis echinochloidea.	0.07	-	-	-
Pentzia sphaerocephala.	0.03	0.05	-	-
Aristida vestita.	0.03	-	0.17	-
Barleria hochuanensis.	0.07	-	-	-
Chrysocoma tenuifolia.	0.03	0.25	0.07	0.03
Aster muricatus.	0.03	-	0.40	-
Tragus racemosus.	0.02	-	-	-
Indigofera patens.	0.03	-	-	-
Walafrida densiflora.	-	0.05	-	-
Commelina africana.	-	0.05	-	-
Enneapogon scoparius.	-	-	0.33	0.10
Heteropogon contortus.	-	-	0.30	0.43
Rhus ciliata.	-	-	-	0.03
Aristida uniplumis.	-	-	0.13	-
Alternanthera repens.	-	-	0.10	-
Panicum coloratum.	-	-	0.07	-
Hypertelis verrucosum.	-	-	0.07	-
Total percentage cover	12.60	4.50	15.70	8.08

(r), (x), (y) and (z): Respectively camps 44, 34, 1 and 4 surveyed in May 1958 for the new research programme.

In.../27

In a survey done according to the modified line-intercept method described by Ebersöhn (1961), on good and poor veld, shrubs were found to have the following percentage canopy cover.

TABLE VI.

PERCENTAGE CANOPY COVER OF UPPER-STOREY VEGETATION ON LIME AND DOLOMITEVELD AT KOOPMANSFONTEIN.

Species.	Limeveld.		Dolomiteveld.	
	Good (j)	Poor (k)	Good (m)	Poor (p)
Tarchonanthus minor.	17.10	1.35	3.15	2.05
T.camphoratus var litakunensis	0.85	2.65	7.70	3.00
Rhus ciliata.	1.30	6.70	5.75	4.55
Grewia cana.	2.10	1.55	2.85	1.80
Olea africana.	1.20	-	2.40	0.20
Rhus lancea.	-	-	0.60	-
Royena pallens.	0.20	-	0.15	0.45
Euclea ovata.	-	0.20	0.10	0.45
Asparagus africanum.	-	0.05	0.30	0.10
Zizyphus mucronata.	-	0.45	-	2.70
Rhus pyroides.	-	-	-	0.35
Lebeckia macrantha.	-	-	-	0.65
Rhus dregeana.	2.70	-	-	-
Royena hirsuta.	-	0.50	-	-
Ehretia rigida.	0.60	-	-	-
Maytenus cymosus.	0.25	0.40	-	-
Total canopy cover (%)	26.30	13.85	23.00	16.30

(j), (k), (m) and (p): Respectively camps 20, 43, 1 and 2 surveyed in May 1958 for the new research programme.

The good limeveld in this example had a Geigeria count of 19 per 300 randomly distributed squares of 200 cm^2 each, while in the poor limeveld the count was 139 per 300 squares.

In.../28

In an investigation on the nutritive value of South African veld, Du Toit, Louw and Malan (1940a) found herbage species grazed by livestock in Griqualand West to have a phosphorous percentage varying between 0.11 and 0.14 in summer and below 0.09 in winter, while the protein percentage varied between 7.0 and 9.0 in summer and between 5.0 and 7.0 in winter.

In Table VII, extracted from a table given by Du Toit, Malan, van der Merwe and Louw (1940b), the monthly availability of phosphates for cattle and sheep on veld of the Ghaap plateau (Region 7) are given.

TABLE VII.

PERCENTAGE PHOSPHATES (P_2O_5) IN PASTURES OF REGION 7. AND DAILY INTAKE OF STOCK : CATTLE + 16 LB. DRY PASTURE AND SHEEP + 1½ LB. DRY PASTURE PER DAY.

	Months.											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Grammes P_2O_5 obtained by steers in grazing.	22	25	20	19	14	12	10	9	9	14	14	19
Grammes P_2O_5 obtained by sheep in grazing.	2.3	2.6	2.1	2.0	1.7	1.5	1.1	0.9	1.0	1.5	1.5	2.0

Daily minimum requirement of a 1,000 lb. growing steer is 23 grammes and that of a 60 lb. growing sheep is 2.5 grammes.

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E. Results in general terms.

This study has shown that, irrespective of the class of livestock grazing the veld, the way in which the veld is managed, and of the grazing pressure brought to bear, the veld reverts to a biotic sub-climax. It consists mainly of seral grasses, with few or more climax, pioneer and weed species present. It is thought to be stable and is highly acceptable to livestock.

Such sub-climaxes appear to be difficult to manage, when in the opinion of French (1957), "the low stocking capacity and the need to accumulate dry-season grazing reserves limit the improvements which are practicable."

Towards the lower end of this biotic sub-climax Geigeria afrikana and Chrysocoma tenuifolia figure very prominently with few or no climax grasses present depending upon the degree of use it has been subjected to. Towards the upper end, climax grasses are more common and the incidence of weeds, pioneers and seral species much lower.

The carrying capacity of the veld was shown to vary widely. Light stocking resulted in undergrazing in summer and during good seasons, and in optimum grazing in spring and in poor years. On the other hand, severe stocking resulted in optimum grazing in summer and during good years, but in over-grazing in winter and during drought years.

In terms of net liveweight gained either on a per steer or per sheep basis, lighter stocking proved superior; but on a per morgen basis heavier stocking proved better.

Judging from the results obtained in these experiments, there is not much to choose between the different systems employed and it is doubtful whether the extra expense of erecting camps, save for the critical spring period is compensated for by increased stock production. Camps no doubt have many advantages, but the present study throws doubts on the economics thereof.

Animal.../30.

Animal production from the various large to small stock ratios did not differ much, except that there is a tendency for per capita gains to be inversely proportional to the number of cattle and sheep in the ratio.

Fixed stocking rates in the drier areas, where the annual rainfall may vary between two-hundred and six-hundred millimeters and where the principal limiting factor in herbage production is moisture, are impractical and fail to make optimal use of herbage. Recurrent over-use and under-use results in that in summer the veld is being undergrazed whilst in winter overgrazing takes place.

The same criticism applies to fixed-rotation, year-long grazing systems. The overruling importance in the amount and erratic distribution of the rainfall, where rains may commence as early as August or as late as March, invalidates all fixed-rotational grazing systems.

A similar criticism may be urged against fixed-ratio, large to small stock numbers. In years of below normal rainfall, herbage is short in stature, low in quantity but excellent in quality and sheep thrive. On the other hand, years of abundant rains resulted in tall growth and herbage high in bulk but poorer in quality, and cattle did better. Fixed ratios of cattle to sheep take no cognisance of these phenomena; either cattle or sheep will suffer depending upon the particular ratio in use and the amount and distribution and time of the commencement of the rains.

Shrubs were browsed mainly in late-winter and spring, the most critical time of the year for both livestock and grasses, but only when little or no other herbage was available.

The practical benefits of a grazing rate in harmony with herbage production is that both vegetation and livestock are in balance and no undue stresses are thrown on either. The condition here is the one suggested by Campbell (1952), namely, of "securing maximum livestock gains during the relatively short pasture season."

Among others, the practical benefits of camps are less selective

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grazing because of greater stock concentration, allowance for plants to attain sufficient leaf area for essential metabolic processes, the prevention of over widening bare areas arising round watering points, the provision of spring grazing reserves and the facilitation of stock management. Until more is known about the growth-rhythm of the principal species which constitute the animals' diet, a system of rotationally grazing two camps, should meet the requirements of both vegetation and livestock.

A practical way in which to make the most of increased herbage growth during seasons of abundance is to stock heavier. Also to arrange the breeding season of cows in such a way that the time during which their demands are heaviest should coincide with the six to seven-month period of summer growth of herbage. In addition, surplus stock, which otherwise would have been sold already, could be held back for some time. Conversely, during dry seasons, lighter stocking, with the earlier disposal of marketable and surplus livestock, appears to be the best way to counteract the disastrous effects of droughts and herbage deficiency in spring.

The practical value of these experiments lies in the fact that they have disproved some popular ideas which at one time or other were deemed advisable. Also that the farm plan must be more flexible to cope with variable rainfall. Then only will farming be in complete harmony with the environment.

The data are also interpreted to furnish evidence that Geigeria-poisoning of livestock appears to be not so much a result of the amount of Geigeria plants present on the veld, but rather of the amount of other herbage in relation to Geigeria.

The work suggests exploring the possibility of stocking the veld to the level of herbage production in good years and of tiding stock over years of scarcity on supplementary fodder as suggested by Crampton (1952).

The high degree of tolerance to grazing exhibited by a number of climax grasses and the fact that the ubiquitious Eragrostis lehmanniana.../32.

niana is highly favoured by stock, suggest that this veld has all the ingredients needed for sustained production. It is essential that a thorough knowledge be acquired of the way in which the component parts of the veld should be manipulated to attain maximum, sustained livestock production, commensurate with conservation and improvement of soil and vegetation.

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farming conditions in the early days of settlement on the Chaap plateau.

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J. Eberson
22/12/61.

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G. Definition of Afrikaans words used in the text.

Bergo	-	Mountains.
Bitterbos	-	Chrysocoma tenuifolia.
Brandsiekte	-	Scab.
Fonteine	-	Springs.
Kalkveld	-	Natural pasturage on limestone surface rock.
Kraal(ed)	-	To bring stock together in a small enclosure, usually of stone, from where they will not stray and where they are reasonably safe from predatory animals.
Lamsiekte	-	Botulism.
Veldtrap	-	The deliberate overgrazing of natural tall-grass pasture to make it more acceptable to sheep.
Pannetjies	-	Circular or almost circular saucer-shaped depressions in the ground, from a few yards to a mile or more across. Only a few feet in depth.
Randjieveld	-	Natural pasturage of hills.
Veld.	-	Natural pasturage.
Vermeerbos	-	The poisonous plant Geigeria africana.
Vermeersiekte	-	Livestock poisoning caused by Geigeria africana.

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CHAPTER II.

EXPERIMENTAL PROCEDURE.

A. Experimental Animals.

Eighteen-months old grade Afrikaner steers and twelve-months old Persian wethers were acquired to evaluate the different grazing experiments. From the outset and whenever fresh animals were introduced at the beginning of seasons, animals were allocated at random to the different experiments. In the case of an animal dying on the experiments, it was replaced by another as similar in liveweight, age and type as was possible. Wethers remained on the experiments for a period of two years, after which they were removed, sold and replaced by fresh year-old wethers. Except at the termination of the experiments, steers remained on the experiments for three years, after which they were slaughtered.

Nicholls (1952) is against the use of older steers in experiments, because he maintains that evaluation is not possible with this class of steer, in that, "from the yearling stage onwards, the requirement for highly nutritious, protein rich fodder progressively declines as the rate of growth diminishes." Concerning the finishing of steers off the veld, he states, "If the natural grassland as it dries off, forms reasonably good and not too fibrous standing hay, some fattening can be carried out, though the proportion of animals brought to prime condition for slaughter is likely to be small." As will be seen from the experiments to be described, the rate of grazing comprised an important factor in the attainment of prime condition.

The removal of steers and sheep from experiments at times of feed scarcity to prevent undue loss of weight or outright loss by death presented difficulties. The method followed was to remove stock when they dropped 20 per cent below their peak liveweight in any season. Stock removal caused the liveweight maintained for that particular season to be lower, owing to there being fewer

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grazing days, while the total digestible nutrients obtained from maintenance was also lower. In fact, losses were lower than what they actually would have been, had the stock remained on the experiments. In spite of seemingly timely removal, a few deaths on the experiments, due to poverty could not be entirely avoided.

Weighing of experimental animals conformed to the recommendations of the American Joint Committee of Pasture and Range Research Techniques (Anonymous, 1952), and consisted of weighing animals just after daylight on each weighday after a 24-hour period of grazing and water starvation. Whiteman et al (1954) consider the with-holding of stock from water and grazing for 24 hours prior to weighing to increase experimental efficiency. In these experiments, fourteen-day weighing intervals in the case of steers and 28-day intervals in the case of wethers, were adopted.

Single liveweight recordings on steers and group liveweight recordings on wethers were carried out on a "Fairbanks" cantilever weighbridge. Weights were recorded to the nearest five pounds. Care was exercised to adhere to fixed times and methods of stock collection in the field, and in weighing procedure. To facilitate identification of individuals and the progressive recording of liveweights, all steers were ear-tagged.

Lush et al (1928) found three-day consecutive weighing to eliminate 42 per cent of the error contained in a one-day weight. Patterson (1947), working with both range-grazed and feed-lot bullocks and comparing the average weight of three consecutive days with a single liveweight, considered that three-day weights were not justified unless the variation of gains was small. Raymond (1956) found animal production adequate for detecting large differences when comparing pastures.

McCullity (1957) supported group live-weight recording in that "the extra preciseness of individual weights would not warrant the additional discomfort or work for the staff." Koch et al (1958

preferred.../38

preferred shrunk weights to fill weights, for shrunk weights were influenced less by fluctuations in fill and were considered to be a more accurate measure of weights and gains. Hervey (1958) held that, "the best evaluation of the range improvement measures is the amount of beef produced per acre rather than the average weight gain of the various steer lots."

Stock management measures included immunization against "lamsiekte", quarter evil, anthrax, blue tongue and pulpy kidney; regular handdressing against external parasites was practised; phosphatic supplementation in the form of bonemeal at the rate of 23 grammes phosphorous pentoxide per steer and 2.5 grammes per wether was supplied; ad lib availability of stock salt; dehorning of all steers; fresh drinking water daily; and all sheep were regularly drenched against internal parasites.

The reaction of animals in different experiments was measured by means of liveweight changes, yield of total digestible nutrients (T.D.N.), deaths, area of the growth curve, slaughter details and in the case of steers, return per morgen and rate of interest on capital invested. Animal reaction to different grazing intensities, grazing systems and large to small stock ratios were regarded as the most important criteria of the suitability of the different experiments in providing for stock all the year round.

(i) Liveweight gain in summer: Stock gained weight rapidly after the first rains in spring or summer. Weights reached a peak six months later after which they either remained constant, or declined until the onset of the next rainy season when they increased once more.

(ii) Liveweight loss in spring: After animals reached peak condition they lost weight to a greater or lesser degree until the first summer rains occurred, after which they picked up condition again.

(iii) Liveweight gain at the end of every season: This constituted the net gain between the commencement and conclusion of every season.

(iv).../39

(iv) Liveweight maintained per morgen: This was calculated according to the formula given by Nevens (1945), as follows:

$$\frac{\text{Average weight over season} \times \text{Length of season in days}}{\text{Number of morgen per steer or per sheep.}}$$

(v) Yield of Total Digestible Nutrients (T.D.N.): This was measured by means of liveweight maintenance, gains and losses in liveweight.

For cattle:

$$\text{Maintenance} = \frac{\text{Liveweight maintained per morgen}}{1000} \times 11.48$$

$$\text{Gains} = \frac{\text{Total seasonal gain per steer}}{\text{Number of morgen per steer}} \times 3.53$$

$$\text{Losses} = \frac{\text{Total seasonal loss per steer}}{\text{Number of morgen per steer.}} \times 2.73$$

For sheep:

$$\text{Maintenance} = \frac{\text{Liveweight maintained per morgen}}{100} \times 1.148$$

$$\text{Gains} = \frac{\text{Total seasonal gain per sheep}}{\text{Number of morgen per sheep}} \times 3.53$$

$$\text{Losses} = \frac{\text{Total seasonal loss per sheep}}{\text{Number of morgen per sheep}} \times 2.73$$

In Annexure 1 a detailed exposition is given of the sources of the formulae used to arrive at the yield of total digestible nutrients obtained.

Armsby (1917) concedes to the use of liveweight as a measure of the aggregate effect of a ration, depending upon the object in view. "If it be one undertaken to answer a commercial question, the increase in liveweight during a considerable period, if determined with the necessary precautions, may be entirely adequate as a measure of the results obtained." Hancock (1952) also supports the measurement of the output of animal products in order to compare various kinds of pastures and pasture management systems.

Könekamp (1952) used starch units to estimate yield of pastures,

while.../40

while Baker et al (1955) prefer the use of starch equivalents (S.E.) which Milford (1960) rejects when applied to subtropical grasses, in that S.E. is based on temperate feeding standards. He suggests in the place thereof that the most suitable criteria for expressing the nutritional values of subtropical grasses are digestible crude protein, nitrogen balance, dry matter intake and dry matter digestibility. However Ivins, quoted by Castle (1955), holds that evaluating a pasture in terms of T.D.N. does not give a reflection of the value of a pasture, but rather of the production of a particular herd, on a particular pasture under specific management.

However, since such closely matched herds and flocks were used and veld was similar when the experiments to be described were started, T.D.N. was used as one of the criteria for comparison. Blaser and Hammes (1956) sound a warning in the per se use of animal gains as criteria of pasture production in that "the rate of gain per animal, when pastured, is much more influenced by winter gain and condition of animals when grazing starts than by animal age." In the experiments to be described, animal group weights were identical or nearly so, for each experiment at the commencement of seasons, and winter gain and condition of animals were therefore disregarded as factors introducing variation.

(vi) Calculation of the area below the growth-curve of experimental animals: Havenga (1961) suggested the use of the rule of Simpson for calculating the area below the growth-curve of each animal. This area is then used as a single measurement of the reaction of the animal to a particular treatment. Seeing that liveweights were taken at 14-day intervals in the case of steers and 28-day intervals in the case of sheep, the requirement that readings should be equi-distant in time, was met. In the case of steers, individual liveweights were available, while in the case of sheep, the mean liveweight of groups were used for area calculation.

(vii) Slaughter particulars: From 1950 onwards, the oldest steer

from.../41

from each experiment was removed at the end of each season, slaughtered, warm carcase graded and weighed to the nearest pound. In addition the wet hide weight was taken to the nearest pound. Offal was compensated for on a carcase-weight basis. Prices obtained were the controlled floor prices for each grade and no auction prices, which might have been influenced by supply and demand, were used. For comparative purposes, the different grades obtained were credited with the following points:-

Super - 11; Prime - 9; Grade I - 7; Grade II - 5; Grade III - 3 and Grade IV - 1.

The final slaughtering at the termination of the experiments in 1957 comprised all the steers from the different experiments, although some of them had then been loss three years in the experiments.

In arriving at the net return realized f[illegible] experiments in which steers were grazed, the purchase pri[illegible] of an eighteen-months old steer was taken at R24 per head and licks and inoculations were estimated to have cost R2 per steer per year. Net profit per morgen per year was obtained by subtracting stock expenditure from the gross return realized by steers during the period the experiment was in existence; this figure was divided by the area of the experiment, and multiplied by the number of years over which the experiment ran.

Rate of interest on capital invested was obtained by dividing the difference between gross return and stock expenditure during the period by total capital investment, and expressing the answer as a percentage. For comparative purposes it is maintained that no veld deterioration took place and that, as a result, land capital remained intact.

B.../42

B. Grazing Systems:

Experimental animals were grazed according to seven different systems of grazing. These are given below.

SYSTEM I.

Four-Seasonal, Three-Camp, One-Herd System.

	First Year				Second Year				Third Year			
Camp No.	Sp	Su	Au	Wi	Sp	Su	Au	Wi	Sp	Su	Au	Wi
1.	G	///	G	////////////////	G	///	G	//////////				
2.	///	G	//////	G	///	G	////////		/////	G		
3.	//////////	G	///	G	//////	G	///	G	////			

Sp = Spring; Su = Summer; Au = Autumn; Wi = Winter; G = Graze in camp and season indicated; /// = Rest camp in season indicated.

SYSTEM II.

Three-Seasonal, Split-Summer, Three-Camp, One-Herd System.

	First Year.			Second Year.			Third Year.		
Camp No.	Sp-Ms	Ms-Au	Winter	Sp-Ms	Ms-Au	Winter	Sp-Ms	Ms-Au	Winter
1.	////////	G		////	G	////	G	///	////////
2.	G	//////////////////		G	////	G	////		
3.	///	G	////	G	//////////////////		G		

Sp-Ms = Spring to midsummer; Ms-Au = Midsummer and Autumn; G = Graze in camp in season indicated; /// = Rest camp in season indicated.

SYSTEM III.../43

SYSTEM III

Three-Seasonal, Split-Winter, Three-Camp, One-Herd System.

Camp No.	First Year			Second Year			Third Year		
	Summer	Au-W(1)	W(2)-Sp.	Summer	Au-W(1)	W(2)-Sp.	Summer	Au-W(1)	W(2)-Sp.
1.	////	G		////	G		////	G	////
2.	G	////	////	G	////	////	G	////	////
3.	////	G	////	G	////	////	G	////	G

Au-W(1) = Autumn and early winter; W(2)-Sp = Late winter and spring; G = Graze in camp and season indicated; //// = Rest camp in season indicated.

SYSTEM IV

This is uncontrolled grazing, where the whole area available to the stock is used continuously, with no rest camps or restrictions to their movement. Stock have access to the whole area all the time, and no concentration of stock is ever practised.

SYSTEM V.

Two-Seasonal, Five-Camp, Two-Herd System.

Camp No.	First Year		Second Year		Third Year		Fourth Year		Fifth Year	
	Ms to Mw	Mw to Ms	Ms to Mw	Mw to Ms	Ms to Mw	Mw to Ms	Ms to Mw	Mw to Ms	Ms to Mw	Mw to Ms
1.	G-A	////	G-A	////	G-B	////		G-B	////	
2.	////	G-B	////	G-B	////	G-A	////		G-A	////
3.	G-B	////	G-A	////	G-A	////	G-B	////		
4.	////	G-A	////	G-B	////		G-B	////	G-A	////
5.	////	////	G-B	////	G-A	////	G-A	////	G-B	

Ms to Mw = Midsummer to midwinter; Mw to Ms = Midwinter to midsummer; G-A = Graze with "A" herd in camp and season indicated; G-B = Graze with "B" herd in camp and season indicated; //// = Rest camp in season indicated.

SYSTEM VI.../44

SYSTEM VI.

Five-Seasonal, Five-Camp, Two-Herd System.

Camp No.	First Year. Sp	First Year. ES	First Year. LS	First Year. W1	First Year. W2	Second Year. Sp	Second Year. ES	Second Year. LS	Second Year. W1	Second Year. W2	Third Year. Sp	Third Year. ES	Third Year. LS	Third Year. W1	Third Year. W2	Fourth Year. Sp	Fourth Year. ES	Fourth Year. LS	Fourth Year. W1	Fourth Year. W2	Fifth Year. Sp	Fifth Year. ES	Fifth Year. LS	Fifth Year. W1	Fifth Year. W2
1.	S	///	///	C	C	S	///	///	C	C	S	///	///	C	C	S	///	///	C	C	S	///	///	C	C
2.	C	C	S	///	///	S	///	///	C	C	C	S	///	///	C	C	S	///	///	C	C	S	///	///	C
3.	///	C	C	S	///	///	C	C	S	///	///	S	///	///	C	C	///	///	C	C	S	///	///	C	C
4.	///	///	C	C	S	///	///	C	C	S	///	///	C	C	S	///	///	C	C	S	///	///	C	C	S
5.	///	///	///	C	C	S	///	///	C	C	S	///	///	C	C	S	///	///	C	C	S	///	///	C	C	S

Sp = Spring; ES = Early Summer; LS = Late Summer ; W1 = First half of Winter; W2 = Second half of Winter; C = Graze with cattle in camp and season indicated; S = Graze with sheep in camp and season indicated; /// = Rest camp in season indicated.

SYSTEM VII.

Three-Seasonal, Five-Camp, Two-Herd System.

Camp No.	First Year. ES	First Year. LS	First Year. Wi	Second Year. ES	Second Year. LS	Second Year. Wi	Third Year. ES	Third Year. LS	Third Year. Wi	Fourth Year. ES	Fourth Year. LS	Fourth Year. Wi	Fifth Year. ES	Fifth Year. LS	Fifth Year. Wi
1.	///	A	GRAZE WHOLE AREA	///	///	GRAZE WHOLE AREA	A	///	GRAZE WHOLE AREA	B	///	GRAZE WHOLE AREA	///	B	GRAZE WHOLE AREA
2.	A	///	GRAZE WHOLE AREA	B	///	GRAZE WHOLE AREA	///	B	GRAZE WHOLE AREA	///	A	GRAZE WHOLE AREA	///	///	GRAZE WHOLE AREA
3.	///	B	GRAZE WHOLE AREA	///	A	GRAZE WHOLE AREA	///	///	GRAZE WHOLE AREA	A	///	GRAZE WHOLE AREA	B	///	GRAZE WHOLE AREA
4.	///	///	GRAZE WHOLE AREA	A	///	GRAZE WHOLE AREA	B	///	GRAZE WHOLE AREA	///	B	GRAZE WHOLE AREA	///	A	GRAZE WHOLE AREA
5.	B	///	GRAZE WHOLE AREA	///	B	GRAZE WHOLE AREA	///	A	GRAZE WHOLE AREA	///	///	GRAZE WHOLE AREA	A	///	GRAZE WHOLE AREA

ES = Early Summer; LS = Late Summer; Wi = Winter; A = Graze "A" herd in camp and season indicated; B = Graze "B" herd in camp and season indicated; /// = Rest camp in season indicated; All five camps are available in winter.

In.../45

In the event of camps being unable to support their stock during any season, animals were turned back to the camps from whence they came. If these camps also became grazed out, animals were removed from the experiments when they had dropped 20 per cent of their peak liveweight. Animals were returned to their camps as soon as grazing became available again, usually after rains.

C. Vegetational Techniques.

The effect of animals upon vegetation was measured by means of vegetation changes occurring under the different experiments. Two methods of estimating species frequency were used. The earlier one used was according to a modified method of Raunkiaer as quoted by Murray (1946).

A three-foot diameter metal circle was repeatedly placed on the ground and the number of plants and their species occurring within the circle, was listed. The method samples the frequency of the various species and not the cover afforded by the vegetation. This method was used up to 1947 and for re-analysis in 1953.

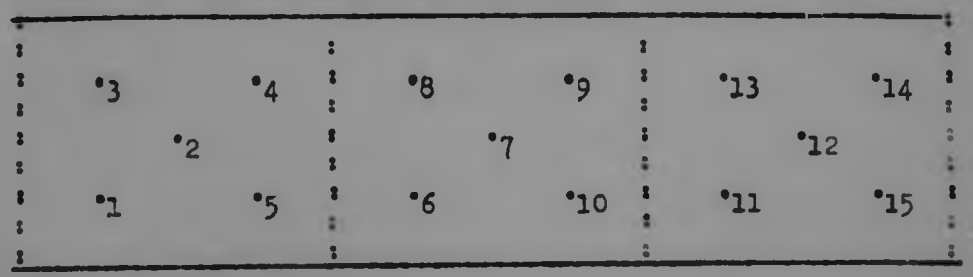
Quadrats were located at predetermined positions, with end quadrats 50 yards from the side fences, while middle quadrats were in the centre of camps. The exact positions of quadrats were marked with a stake driven into, and almost flush with the ground, thereby rendering the quadrats permanent. These quadrats were re-analysed in March 1953 at the conclusion of the first set of experiments.

Fig. I shows the predetermined positions at which quadrats were placed.

Fig.I.../46

FIG. 1.

Positions of quadrats in relation to the side fences of camps.



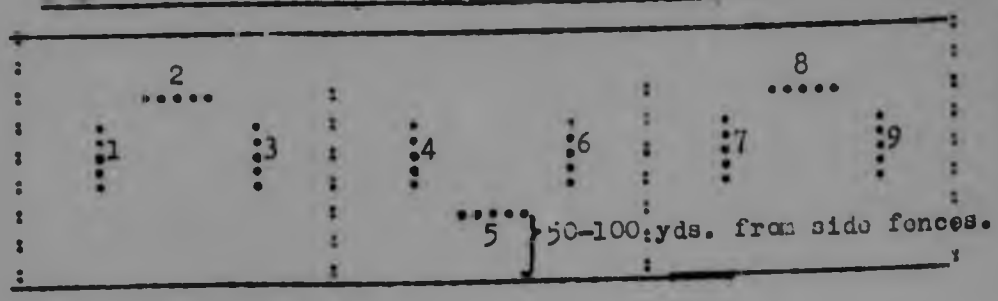
The second method, used from 1950 onwards, is similar to that described by Von Broembsen (1951), except for the fact that the centre chain only was used, and recording sites were between 50 and 100 yards away from the side fences. The centre chain was situated between two permanent markers, one always up against a shrub and a tag was placed on the nearest fence to facilitate relocation of the site.

The method of recording the species present was as follows: Five metal rings of two feet diameter were placed in fixed positions along the centre chain. Each ring was divided into four quadrants by means of a metal cross which was placed on the ring. The species occurring in each ring were listed together with the number of quadrants in which they occurred. This gave a frequency number of 0-4 for each ring, a total of 0-20 for each chain, or an aggregate of 0-60 for each camp, three chains being placed in every camp.

Fig. II shows the predetermined positions at which chains of quadrats were placed.

FIG. II.

Positions of chains in relation to the side fences of camps.



Regarding.../47

Regarding the estimates of plant frequency, three aspects must be borne in mind. Firstly, the counts were only undertaken in the third season after commencing the experiments. This means that considerable vegetation changes could have taken place before the initial estimates were made. In the second place, the methods of survey did not include an estimate of shrub frequency. The shrubs which are mentioned in the plant frequency tables were isolated seedlings and are no reflection of the number of shrubs involved. In addition, estimates of Geigeria frequency were not undertaken annually. Afterwards it transpired that it is a necessity because of wide variation in Geigeria populations from year to year. This fluctuation invalidates conclusions drawn from initial and terminal counts only.

In order to investigate animal preferences, veld utilization during different seasons and plant/soil interrelationships on the veld under the conditions imposed by the different experiments, critical observations of these phenomena were made in summer, autumn and spring each year. To accomplish this, all camps were traversed on foot along the diagonals, following alternate diagonals in successive years. All observations were recorded on field sheets and later indexed.

D. Soil sampling and analysis:

Soil samples were collected from all grazing experiments after their conclusion. Ten sites per experiment were systematically chosen. At each site a spade-block sample, two inches thick, of the 0-3 inch, 3-6 inch and 6-12 inch horizons was cut after leaves and litter were removed from the surface of the soil.

The ten sub-samples obtained from each horizon were then dumped together. After thorough mixing of the soil it was halved and quartered, and a composite sample, weighing approximately two pounds, was obtained for mechanical and chemical analyses. The soil was then passed through a 2 m.m. screen, except for organic carbon in

which.../48

which case it was passed through a 0.5 m.m. screen and crushed.

All chemical and mechanical analyses were done by Mr. D.F.M. Claassen of the Chemistry section at the Glen Agricultural College. Internationally accepted methods of analysis were used.

E. Statistical analysis of the data.

The index of disperion , (χ^2) was used for the statistical analysis of species frequency estimates according to the method described by Von Broembsen (1951). It was assumed that a correlation existed between the observations of the four quadrants of each metal ring. Comparisons were made only between seasons within the same experiment and not between different experiments. For the purpose of the analysis the presence or absence of species in quadrats was used. For experiments with one camp, 60 quadrats, for those with three camps, 180 quadrats and for those with five camps, 300 quadrats were available. Since frequency recorded only presence and absence of species in quadrats, the estimates were not additive.

For the modified method of Raunkaier, as quoted by Murray (1946), no statistical test of significance was possible because details of the number of plants counted per quadrat in 1947 were lost, only the aggregate number of plants present in all quadrats per experiment being available. There is no way in which the repeatability of the data could be analysed. Since the actual number of plants was recorded in the Raunkaier method, the count of different species were additive.

For statistical analysis of liveweight data, the area of the growth-curve was calculated according to the rule of Simpson, as given by Havenga (1961). When the growth-curve areas of two paired animals or two paired groups of animals were compared to determine whether the area of the one animal or group of animals was significantly greater than that of the other animal or group of animals over the whole period, the U-test of Mann-Whitney, as

given... 49

given by Siegel (1956), was used.

When three or more growth-curve areas were compared to determine which were the greater over the whole period, the H-test of Kruskall-Wallis, as given by Siegel (1956), was first done to determine whether the areas were drawn from the same universum. Subsequently, the U-test of Mann-Whitney was applied on either one pair of animals, or on two groups of paired animals, depending upon what wa[illegible] in the experiments.

[illegible]bability consulted were Table A - page 247, Table C - [illegible]ble K - pages 247 to 277 in "Nonparametric Statistics", by S. Siegel (1956)

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CHAPTER III.

THE EFFECT OF STOCKING RATE AND ROTATIONAL GRAZING ON BEEF PRODUCTION.

Current farming practice on the Chaap plateau is to allow cattle to breed without restriction and with little regard to the stocking rate and to sell off cattle in some quasi-marketable condition. During every winter and spring cows are lost from poverty, and in addition large numbers die during droughts. Some farmers resort to buying up steers at the commencement of the rains, let them grow out during summer and autumn, and sell them in winter and spring. Very little supplementary feed is given except to lactating cows used in dairy-ranching. The veld is grazed continuously and stock is put in every camp at the dictates of the farmer's fancy or as animal measures may require.

Even on farms planned according to the Soil Conservation Act (Anonymous, 1946), a laisez-fair policy prevails. In terms of the Act farmers are helped financially in the construction of soil conservation features such as watering points and fences. In return they are bound by law not to exceed certain numbers in stocking and to graze camps in a prescribed rotation. In practice little attention is paid to these prescriptions.

Because of the wholesale retrogression of the veld, the poor condition of cattle and a high rate of death loss due to poverty, two series of experiments, employing steers as year-long grazers of veld, were carried out to compare:-

A. Two grazing intensities using grazing system III, and

B. Two grazing systems at a stocking rate of eight morgen per steer.

Their purpose was to determine how the veld could be managed so that cattle would derive maximum benefit commensurate with veld conservation and improvement.

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CHAPTER III.

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A.../51

A. GRAZING INTENSITIES.

Under both rates of grazing the experiments were carried out on lime and dolomiteveld according to grazing system III. They were initiated in June 1948 and discontinued in July 1957. Table VIII gives details of the four experiments.

TABLE VIII.

GRAZING INTENSITY WITH CATTLE ON VELD.

Experiment No.	Particulars.
10 L	Limeveld: 3 steers to 36 morgen.
11 L	: 3 steers to 18 morgen.
10 D	Dolomiteveld: 3 steers to 36 morgen.
11 D	: 3 steers to 18 morgen.

Veld and steer interaction was measured by means of

(1) Frequency estimates of plants,

(2) Field observations,

(3) Soil analysis,

(4) Liveweight changes, deaths and departure from systems,

(5) Liveweight-curve area,

(6) Slaughter details, and

(7) Geigeria poisoning.

(1) PLANT FREQUENCY ESTIMATES:

In Tables IX and X the change in species frequency between 1951 and 1957 is given for limeveld and dolomiteveld respectively.

TABLE IX.../52

TABLE IX.

PLANT RESPONSE TO TWO GRAZING INTENSITIES WITH CATTLE ON LILIEVELD AT KOOPMANSFONTEIN.

	Frequency per 180 quadrats (s)			
	Expt. 10 L(12m)		Expt. 11 L(6m)	
CLIMAX SPECIES:	1951	1957	1951	1957
Themeda triandra	27	38	6	8
Chrysopogon montanus	19	20	15	6*
Fingerhuthia africana	18	6*	11	2*
Cymbopogon plurinodis	16	24	18	22
Digitaria eriantha	5	5	16	1**
Sporobolus fimbriatus	3	0	3	0
Eustachys paspaloides	2	0	1	0
Aristida vestita	0	0	1	1
SERAL SPECIES:				
Eragrostis lehmanniana	91	136**	90	150**
Tragus koelerioides	21	0**	6	0*
PIONEER SPECIES:				
Cropetium caponse	20	42**	33	79**
Enneapogon brachystachyus	19	45**	20	36*
Aristida curvata	16	18	9	5
Tragus racemosus	9	2*	18	5**
WEEDS:				
Geigeria africana	39	113**	31	110**
Chrysocoma tenuifolia	14	2**	21	6**
Tribulus terrestris	0	2	0	1
KAROID SPECIES:				
Aster muricatus	11	38**	15	11
Nonechma divaricatum	0	8**	9	15
Indigofera patens	0	6**	3	3
OTHER SPECIES:				
Woody	9	8	2	0
Herbaceous	32	81**	19	127**

Woody species comprise the genera Maytenus, Tarchonanthus and Asparagus.

Herbaceous species comprise the genera Blepharis, Pharnaceum, Walafrida, Hermannia, Euphorbia, Barleria, Hibiscus, Commelina, Sericorema, Oxalis and Stachys.

(s) = Surveys according to the method by Von Broembsen (1951).

* = Significant difference at P = 0.05.

** = Significant difference at P = 0.01.

TABLE X.../53

TABLE X.

PLANT RESPONSE TO TWO GRAZING INTENSITIES WITH CATTLE ON DOLOMITEVELD AT KOOPMANSFONTEIN.

	Frequency per 180 Quadrats (s)			
	Expt. 10 D(12m) :		Expt. 11 N(6m)	
CLIMAX SPECIES:	1951	1957	1951	1957
Digitaria eriantha	11	12	7	3
Heteropogon contortus	7	11	5	2
Sporobolus fimbriatus	3	1	4	3
Cymbopogon plurinodis	3	3	1	3
Chrysopogon montanus	3	0	18	18
Themeda triandra	2	1	2	7
SERAL SPECIES:				
Eragrostis lehmanniana	107	159***	127	142***
Eragrostis obtusa	4	4	0	24***
E. denudata	1	5	1	0
E. echinchloidea	0	11	0	14***
Enneapogon scoparius.....	2	0	0	0
PIONEER SPECIES:				
Oropetium capense	51	83***	77	138***
Aristida curvata	35	11***	7	9
Enneapogon brachystachyus	34	25**	24	35***
Tragus racemosus	32	2***	30	12***
Brachiaria eruciformis	0	2	0	1
WEEDS:				
Chrysocoma tenuifolia	18	10	2	15***
Geigeria africana	2	5	1	12***
Tribulus terrestris	1	0	1	2
KARROID SPECIES:				
Indigofera patens	2	5*	1	0
Aster muricatus	1	19***	1	5
OTHER SPECIES:				
Woody	1	2**	5	4***
Herbaceous	10	32***	7	103***

Woody species comprise the genera Asparagus, Rhus, Maytenus, Tarchonanthus and Euclea.

Herbaceous species comprise the genera Sericorema, Commelina, Walafrida, Oxalis, Hypoxis, Cyperus, Amaranthus, Pentzia and Hermannia.

*** = Significant difference at P = 0.01

(s) = Surveys according to a method by Von Broembsen (1951).

Because.../54

Because of late commencement of initial plant counts and inadequacy of the method, only large changes in the species frequency will be considered.

Themeda triandra and Cymbopogon plurinodis are conspicuous as the species which were best able to tolera e grazing by cattle under both intensities and on both veld types. In addition Chrysopogon montanus and Digitaria eriantha tolerated light grazing on lime. Sporobolus fimbriatus, Chrysopogon montanus, Digitaria eriantha and Heteropogon contortus appeared to be equally tolerant to both light and severe grazing on dolomiteveld. Fingerhuthia africana on both severely and lightly grazed limeveld was intolerant to cattle grazing.

The frequency of Chrysocoma tenuifolia declined except in the case of severely grazed dolomite. Because of high seasonal variation, no inferences from the plant counts of Geigeria africana, for the two seasons in which plant counts were made, are justified.

(2) FIELD OBSERVATIONS:

Steers preferred Eragrostis lehmanniana, Fingerhuthia africana and Themeda triandra and discriminated against Cymbopogon plurinodis and Heteropogon contortus under light grazing. From midsummer onwards as the grasses reached maturity, steers preferred grass leaves to stems. Under severe grazing neither protracted preferences nor continued discriminations took place and all herbage was taken with alacrity. The annual Aristida curvata was well grazed in early summer but then avoided until seedheads were again eagerly sought after in winter.

From midwinter until the occurrence of rains, when steers took to grass, they lightly browsed on shrubs, preferring Tarchonanthus minor. Under severe grazing, shrubs were heavily browsed throughout the year and even Tarchonanthus camphoratus var. litakunensis (which shed its leaves during drought), Rhus ciliata and Grewia cana were taken. These species were normally avoided under light grazing.

In spring, Eragrostis lehmanniana was the first to sprout, followed by Chrysopogon montanus, Cymbopogon plurinodis, shrubs and

other.../55

other grasses. Cymbopogon plurinodis and Heteropogon contortus were grazed in spring only under severe grazing. Grass, either green, matured or dry, was always available in one or other lightly grazed camp. In severely grazed camps grasses were cropped short long before the onset of the first summer rains.

Under light grazing, grasses were vigorous and formed a continuous stand with bare areas confined to exposed rock. Under severe grazing grasses on lime were largely replaced by annuals and ruderals, and tuft grasses were confined to cracks and crevices in the rock. Tufts were reduced to a few shoots, and bushes became stunted shrublets, three to four feet in height, with only their trunk branches remaining.

Under light grazing, shrubs constituted a continuous, well-leafed upper storey. Utilization was of such an order that stems of grasses and some leaves and twigs of shrubs remained uneaten at times of camp changes and at the onset of summer rains.

(3) SOIL ANALYSIS:

In Tables XI and XII particulars are given of physical and chemical analyses of soils obtained from lime and dolomiteveld respectively, after being subjected to the different rates of grazing for a period of nine years.

TABLES XI.../56

TABLE XI.
(s)

MECHANICAL AND CHEMICAL ANALYSES OF LIMPVELD SOILS UNDER TWO GRAZING INTENSITIES WITH CATTLE AT KOOPMANSFONTEIN.

	Experiment 10 L(12m)			Experiment 11 L(6m)		
Soil horizon (inches)	0-3	3-6	6-12	0-3	3-6	6-12
pH	6.83	6.84	7.38	7.50	7.06	6.65
Resistance at 60°F.	1500	1370	1300	1250	1520	1330
Mechanical analysis (%):						
Sand (>.02mm).	82.29	84.83	84.79	83.42	81.66	77.67
Silt (.02 - .002 mm).	7.45	6.78	5.56	7.81	7.55	7.62
Clay (< .002 mm).	10.26	8.39	9.65	8.77	10.79	14.71
$CaCO_3$ (%)	0.00	0.00	0.00	0.00	0.00	0.00
P (%)(z)	.0021	.0009	.0008	.0027	.0010	.0004
C (%)	1.08	0.81	0.51	1.22	0.93	0.62
N (%)	0.12	0.09	0.07	0.12	0.10	0.07
C : N ratio.	9.2:1	9.3.1	7.6:1	10.3:1	9.4:1	9.1:1
Water-soluble salts(%)(n):						
Na.	.0008	.0009	.0008	.0010	.0007	.0008
K.	.0008	.0003	.0002	.0009	.0005	.0003
Ca.	.0033	.0031	.0041	.0054	.0028	.0026
Mg.	.0001	.0002	.0010	.0004	.0014	.0001
HCO_3	.0085	.0090	.0142	.0154	.0074	.0064
Cl.	.0035	.0038	.0027	.0030	.0030	.0027

(z) = 1% Citric acid solution.

(n) = Soil : Water :: 1 : 2.

(s) = Analyses by D.F.M. Claassen.

Limeveld soil under light grazing becomes more alkaline, the sand fraction increases, while the clay fraction decreases, and the calcium, magnesium and bicarbonate content increases with increasing depth of soil. The reverse holds good for soils under severe grazing. The carbon status of soil under severe grazing is higher than that of soil under light grazing and with a similar nitrogen status under both intensities. A wider carbon : nitrogen ratio is found under severe grazing.

TABLE XII.../57

TABLE XII.

MECHANICAL AND CHEMICAL ANALYSES(s) OF DOLOMITEVELD SOILS UNDER TWO GRAZING INTENSITIES WITH CATTLE AT KOOPMANSFONTEIN.

	Experiment 10 D(12m)			Experiment 11 D(6m)		
Soil horizon (inches)	0-3	3-6	6-12	0-3	3-6	6-12
pH	7.51	7.58	7.73	7.55	7.70	7.67
Resistance at 60°F.	1000	800	900	1220	1200	950
Mechanical analysis (%):						
Sand (>.02 mm).	78.21	79.61	68.28	82.25	80.95	80.00
Silt (.02 - .002 mm).	12.10	10.69	22.71	9.37	10.78	7.56
Clay (<.002 mm).	9.69	9.70	9.01	8.38	8.27	12.44
$CaCO_3$ (%).	0.46	0.49	9.50	0.46	1.75	0.55
P (%)(z).	.0046	.0050	.0075	.0034	.0030	.0024
C (%).	1.14	1.22	1.26	0.71	0.74	0.66
N (%).	0.11	0.11	0.11	0.09	0.08	0.08
C:N ratio.	10.2:1	11.1:1	11.5:1	8.1:1	9.0:1	7.9:1
Water-soluble salts (n):						
Na.	.0012	.0011	.0008	.0008	.0009	.0010
K.	.0014	.0011	.0009	.0010	.0003	.0002
Ca.	.0055	.0059	.0056	.0046	.0042	.0052
Mg.	.0008	.0001	.0012	.0007	.0007	.0008
HCO_3.	.0195	.0164	.0185	.0159	.0185	.0154
Cl.	.0035	.0035	.0030	.0035	.0027	.0032

(z) = 1% Citric acid solution.

(n) = Soil : Water :: 1 : 2.

(s) = Analyses by D.F.M. Claasson.

With increasing depth, the silt fraction of dolomite soil under light grazing increases, while the clay fraction decreases, the phosphorus status increases, the carbon-nitrogen ratio widens and the sodium content decreases. These tendencies are reversed for soils under severe grazing. Both the phospherus and carbon status of dolomite soil under light grazing tend to be higher than that under severe grazing.

(d).../58.

(4) LIVEWEIGHTS:

In Tables XIII and XIV the average liveweight gains and losses, liveweight maintained and total digestible nutrients obtained are given for steers grazing lime and dolomiteveld at two stocking intensities.

TABLE XIII.../59.

TABLE XIII.

GAINS AND LOSSES PER STEER(n) : LIVEWEIGHT MAINTAINED AND T.D.N. OBTAINED IN POUNDS PER MORGEN UNDER TWO RATES OF GRAZING ON LIMEVELD.

Seasons.	Total Rainfall(m.m.)	Expt. 10 L (12 m./steer). Summer Gain	Spring Loss.	Net Gain	Liveweight maintained per morgen	T.D.N. per morgen	Expt. 11 L (6 m./steer). Summer Gain	Spring Loss.	Net Gain.	Liveweight maintained per morgen	T.D.N. per morgen
1948/49	151	268	101	167	28805	386	185	155	30(p)	43787	540
1949/50	588	471	161	310	37715	535	396	189	207	59400	829
1950/51	470	225	24	201	21216	304	192	53	139	39117	538
1951/52	288	289	187	102	24111	322	173	107	66(s)	37196	480
1952/53	418	348	133	215	22582	331	164	180	-16(rt)	33768	402
1953/54	378	418	88	330	23499	373	323	95	228	30008	491
1954/55	459	264	151	113	24516	325	172	132	40	39481	268
1955/56	563	341	81	260	24904	368	268	45	223	45743	662
1956/57	427	335	83	252	26082	379	222	88	134	49457	658
Mean/season	419	329	112	217	-	-	233	116	117	-	-
Mean/morgen/season.		27	9	18	25937	369	39	19	20	41995	541

(n) = Weights are the mean of three steers.

(p) = Steers removed from 26/10/49 to 10/1/50.as a result of shortage of grazing.

(s) = One steer died from poverty. Steers removed from the experiment due to herbage shortage.

(r) = Steers removed from experiment from 30/12/52 to 10/2/53 due to herbage shortage.

(t) = Two steers died from poverty.

TABLE IV.../60

TABLE XIV

GAINS AND LOSSES PER STEER(n) : LIVEWEIGHT MAINTAINED AND T.D.N. OBTAINED IN POUNDS PER MORGEN UNDER TWO RATES OF GRAZING DOLOMITEVELD.

Seasons.	Total Rainfall (m.m.)	Expt. 10 D (12 m/steer) Summer Gain.	Spring Loss.	Net Gain	Liveweight maintained per morgen	T.D.N. per morgen	Expt. 11 D (6 m./steer). Summer Gain.	Spring Loss.	Net Gain	Liveweight maintained per morgen	T.D.N. per morgen
1948/49	151	217	139	78	27040	343	152	142	10(p)	43428	523
1949/50	588	469	141	328	35435	513	442	204	208	59700	835
1950/51	470	293	82	211	20572	474	216	82	134	22002	551
1951/52	288	227	133	94	25384	328	189	222	-33(ts)	43577	509
1952/53	418	376	101	275	26183	388	260	173	87	42322	570
1953/54	378	419	111	308	24782	363	383	203	180	43409	632
1954/55	459	243	147	96	23047	312	195	197	-2	41184	498
1955/56	563	321	36	285	24752	370	308	90	218(t)	37249	568
1956/57	427	311	82	229	25661	361	266	131	135	42616	605
Mean/season.	419	320	108	212	-	-	265	161	104	-	-
Mean/morgen/season.		27	9	18	25962	386	44	27	17	41724	588

(n) - Weights are the mean of three steers.

(p) - Steers removed from 26/10/49 to 10/1/50 due to herbage shortage.

(t) - One steer died from poverty.

(s) - Steers removed from 10/1/52 to 12/2/52 due to no herbage being left to graze.

On.../61

On a per steer basis, light grazing led to higher weight gains in summer and a lower spring liveweight loss. This enabled steers to conclude the season at about twice the net gain shown by steers on severely grazed veld. On a per morgen basis severe grazing resulted in higher summer gains and in two to three times the spring loss exhibited during light grazing. Net gains were similar in all experiments. Higher liveweight maintenance and more total digestible nutrients were obtained from severe grazing.

Severe grazing failed on several occasions and necessitated the removal of steers from the experiments. Five steers died on severe grazing. Lime and dolomitoveld resulted in similar steer gains. There is no evidence that either a decrease or an increase in production took place over the nine years.

On an average, 76 per cent of the T.D.N. obtained went to maintenance, and of the 24 per cent diverted to gains, 9.5 per cent in the case of severe grazing and 6 per cent in the case of light grazing was lost in spring.

(5) LIVEWEIGHT-CURVE AREA.

In Tables XV and XVI the area of the liveweight-curve of ten matched pairs of steers, for both lime and dolomiteveld, are given together with levels of significant differences between areas.

TABLE XV.../62

TABLE XV.

AREA BELOW THE LIVEWEIGHT-CURVE OF STEERS GRAZING LIMEVELD AT TWO STOCKING INTENSITIES.

Period on Experiment.	Experiment 10 L (12m): Steer No.	Area	Experiment 11 L (6m): Steer No.	Area	Calculated Values of: z	P	Significant Differences (P ≤0.01)
8.6.48 to 5.1.51	2449	77883	2495	62324	4.81	<.001	10 L > 11 L
8.6.48 to 14.8.51	153	91185	2499	77178	1.99	.024	N.S.
8.6.48 to 1.7.52	39	113637	2404	83525	5.13	<.001	10 L > 11 L
6.1.51 to 15.7.53	E.18	56232	E.24	52437	2.83	.003	10 L > 11 L
15.8.51 to 13.7.54	E.17	54740	E.23	46482	2.83	.003	10 L > 11 L
2.7.52 to 12.7.55	E.16	56738	K.97	45563	4.64	<.001	10 L > 11 L
16.7.53 to 10.7.56	254	63207	255	44710	6.86	<.001	10 L > 11 L
14.7.54 to 6.7.57	407	64227	417	67837	2.40	.009	10 L < 11 L
13.7.55 to 6.7.57	505	37048	504	37622	0.69	.246	N.S.
11.7.56 to 6.7.57	603	17355	655	14502	2.97	.002	10 L > 11 L

TABLE XVI.

AREA BELOW THE LIVEWEIGHT-CURVE OF STEERS GRAZING DOLOMITEVELD AT TWO STOCKING INTENSITIES.

Period on Experiment.	Experiment 10 D (12m): Steer No.	Area	Experiment 11 D (6m): Steer No.	Area	Calculated Values of: z	P	Significant Differences (P ≤0.01)
8.6.48 to 5.1.51	2402	70647	2506	62086	2.42	.008	10 D > 11 D
8.6.48 to 14.8.51	2287	91425	2412	83618	2.93	.002	10 D > 11 D
8.6.48 to 1.7.52	2448	107110	2332	89892	2.34	.010	10 D > 11 D
6.1.51 to 15.7.53	E.20	70157	E.27	59046	2.92	.002	10 D > 11 D
15.8.51 to 13.7.54	E. 9	65970	E.26	51806	5.48	<.001	10 D > 11 D
2.7.52 to 12.7.55	177	57904	E.25	58620	0.66	.245	N.S.
16.7.53 to 10.7.56	246	57757	E.35	47903	4.47	<.001	10 D > 11 D
14.7.54 to 6.7.57	410	64795	419	59532	6.09	<.001	10 D > 11 D
13.7.55 to 6.7.57	520	34960	503	29245	2.86	.031	N.S.
11.7.56 to 6.7.57	604	16914	628	18823	3.79	<.001	10 D < 11 D

Steers .../63

Steers grazing either lime or dolomiteveld at the rate of one steer to twelve morgen had a significantly bigger liveweight-curve than steers grazing at the rate of six morgen per beast. This applied in the case of seven out of ten steers. In one pair of steers the reverse held good, while in the case of two other pairs no significance could be established.

(6) SLAUGHTERINGS:

Slaughter particulars, capital investment, profit and rate of interest earned are given in Table XVII for the two grazing intensities on lime and dolomiteveld respectively.

TABLE XVII.../64

TABLE XVII.

SLAUGHTER PARTICULARS(n) AND FINANCIAL RETURNS(z) OF STEERS UNDER TWO RATES OF GRAZING AT KOOPMANSFONTEIN.

	Limeveld.		Dolomiteveld.	
	Expt.10 L: 12m/steer	Expt.11 L: 6m/steer	Expt.10 D: 12m/steer	Expt.11 D 6m/steer
Farm liveweight in lb.	1178	926	1178	937
Warm carcase-weight in lb.	639	460	634	469
Dressing percentage.	54	50	54	50
Grade.	Prime	II	Prime	II
Wet hide-weight in lb.	73	53	72	53
Capital investment.				
Land at R12 per morgen	R432	216	432	216
Steers at R24 each.	R240	240	240	240
Replacement steers at R24 ea:		R72(t)		48(k)
Licks and inoculations.	R 54	54	54	54
Total capital investment.	R726	582	726	558
Gross return from 10 steers over 9 years.	R630.97	396.32	635.03	349.43
Less stock expenditure.	R294	366	294	342
Excess of gross return over stock expenditure.	R336.97	30.32	342.03	47.43
Area of expts. in morgen.	36	18	36	18
Profit per morgen per year.	R 1.04	18c	R 1.06	29c
Rate of interest per annum.	5.16%	0.58%	5.23%	0.94%

(n) = Particulars are the mean of ten steers for every experiment.

(z) = Financial particulars are the total for every experiment.

(t) = Three steers died as a result of poverty and had to be replaced.

(k) = Two steers died as a result of poverty and had to be replaced.

On.../65

On a per steer basis, steers from lightly grazed veld dressed and graded better and yielded heavier carcases and hides than steers from severely grazed veld. Consequently, light grazing resulted in four times as much profit on dolomiteveld and six times as much profit on limeveld when compared to severe grazing.

The meagre profits obtained from severe grazing led to extremely poor rates of interest.

(7) GEIGERIA-POISONING:

During the course of nine years no "vermeersiekte" nor any deaths as a result of Geigeria-poisoning occurred in any of the experiments. Therefore this criterion falls away as a means of judging these grazing rates.

DISCUSSION:

The evidence that botanical changes did not differ appreciably under the two rates of grazing, after nine years, does not entirely agree with results obtained by Gard, Fuelleman, Van Doren and Yamslade (1943) in Illinois, McKay (1956) in Southern Rhodesia, and with findings in Wyoming (Anonymous,1957). All these investigators found that severe grazing led to an increase of both weeds and annuals and to a decrease in perennial species. In the case of severely grazed dolomite the frequency of climax grasses remained constant while that of pioneer and seral species actually increased under severe grazing on both lime and dolomiteveld.

As an explanation for this anomaly it is suggested that part of the grazing pressure under severe grazing was drawn off to another source of herbage inadvertently omitted from the counts, namely shrubs. The heavily browsed condition of shrubs in the case of severe grazing compared with that of shrubs under light stocking rate bears this out.

The decline in frequency of climax species on severely grazed limeveld and the greater abundance of seral, karroid and herbaceous species in all experiments suggest a rearrangement of the components of the sward towards what may be called a biotic sub-climax under

cattle.../66

cattle grazing. A change in habitat occurred. Cannon (1924) is of the opinion that under arid conditions, "the relations are largely between the plants and the habitat rather than between the plants themselves." In other words, he regards inter-species competition in arid zones of less importance than the individual plant's struggle for survival. Phillips (1931) also expresses himself very strongly on the close relationship existing between plants and animals, in fact, he regards them as "inter-related, co-acting constituents of an integrated community."

The veld on which these experiments were laid out was much closer to the climax in the case of lime than in the case of dolomite. On dolomiteveld the status quo was maintained from 1951 to 1957, but not so in the case of severely grazed limeveld where the development was decidedly towards a biotic sub-climax. Given the necessary time, veld under light grazing would in all probability end up in much the same condition as that under severe grazing.

Although veld enclosures existed alongside and throughout the duration of these experiments, no plant counts were undertaken and a valuable control for the grazing experiments was lost. In this connection Hanson (1952) emphasizes that in the event of areas under two intensities of treatment being compared, an additional check against a natural area is desirable.

The difficulty experienced in controlling Cymbopogon plurinodis on lime and Heteropogon contortus on dolomite was in large measure caused by them being grazed as a last resort only. Consequently they largely grow unchecked

The decline in frequency of Fingerhuthia africana under both intensities on lime and of Chrysopogon montanus and Digitaria eriantha on severely grazed lime is due to these grasses being highly preferred by cattle. Their susceptibility to severe grazing makes these species sensitive indicators of veld condition in that an abundance of them would suggest conditions approaching the climax. Conversely, should they occur infrequently or be entirely absent, it would indicate a stage low in the succession.

It.../67

It is an auspicious coincidence that Eragrostis lehmanniana and Themeda triandra, both particularly sought after by cattle, should also prove to be most tolerant to grazing. In addition, it is fortunate that summer annuals and pioneers persisted and even increased, for they provided abundant herbage just after the first rains. This eased the grazing pressure on freshly sprouted and therefore highly vulnerable perennial tuft grasses. These ephemerals do not enter into competition with perennials for moisture and in addition, Humphrey (1959) showed that summer annuals were more efficient in their water-use than perennials. He also found that perennials used little water until late summer when they came into competition with shrubs and half-shrubs. These, in turn, used water most heavily in late-summer and again in spring.

The appreciable decrease in Chrysocoma tenuifolia on lime as against a significant increase in the case of severely grazed dolomite and an insignificant decrease on lightly grazed dolomite may be due, in part, to soil development in the case of lime, prevention of soil development in the case of severely grazed dolomite and retardation of soil development in the case of dolomite being lightly grazed.

The lime soils from these experiments were found to contain a much lower percentage of silt than clay, while the reverse was true in the case of dolomiteveld. In turn, soil from severely grazed dolomite, as against soil from lightly grazed dolomite, contained appreciably more sand content but much less silt and less clay. In England, Perring (1958) found that cattle, by excessively treading chalk grassland, "may break the surface of vegetation, expose the soil and retard the rate of soil development by keeping it in a relatively juvenile state." With regard to brush encroachment and grazing intensity, Harris (1958) found that yields of sagebrush increased as a result of increased stocking rates. In the Big Horn Mountains of Wyoming (Anonymous, 1957a), the crown areas of sagebrush were found to have increased under all grazing treatments. The increase

was.../68

was found to be almost twice as much under heavy grazing as under light grazing. This resembles the results obtained on severely grazed dolomite.

It is to be deplored that annual counts of Geigeria africana were not undertaken. At the time the large annual variation in its frequency could not be foreseen. Such counts would no doubt have thrown much light on the reaction of this species to conditions in the biotic sub-climax under cattle grazing.

The methods of botanical analysis used did not include the shrubs and it is therefore impossible to judge the effect of the animals on these plants. However, shrubs provided herbage in late winter and spring in the case of light grazing and all the year round in the case of severe grazing. Halls, Hale and Knox (1957), working with cattle in burnt-over ranges in Georgia, found a similar result in that grasses contributed the bulk of cattle feed throughout the year, while the contribution of browse plants varied, reaching as much as 31 and 13 per cent in December and April respectively but contributing little during June and September.

Whether the reduction of shrubs to dwarf shrublets was another step nearer to their eventual destruction or whether they would survive in their stunted growth form is open to conjecture. Of the wild-olive (Olea africana) Acocks (1939) believes "it is almost impossible to kill these plants by grazing; anybody who has travelled about the Cape Plateau must have seen the strange little dwarfed olives along roads and on commonages where they defy even the goats." In these experiments, shrubs proved most acceptable to and the mainstay of steers under severe grazing.

On the other hand, the only shrub in the lightly grazed experiments ever to be browsed at all was Tarchonanthus minor. This may eventually lead to this species being killed out. Acocks (1953) confirmed this by stating, "while valuable fodder shrubs like Tarchonanthus minor are suffering the usual fate of useful plants being killed out."

A factor which may have had a pronounced effect on stock production.../69

tion was the closure of the summer-grazed camp during autumn, winter and spring, although abundant browse was present in such camps. This measure is considered to have been deleterious to stock, especially in the case of steers under severe grazing. These steers invariably had to fall back on shrubs to satisfy their hunger and the availability of an additional two morgen of shrubs per steer in these months might have enabled steers under severe grazing to have been overwintered with less loss in liveweight. It might also have helped considerably in easing the weight of grazing pressure from the already short-cropped grasses. On the other hand, the long rests camps received once in three years were probably of great value to shrubs in enabling them to regain vigour after two years of severe browsing.

The fact that under severe grazing, all grass species were equally well grazed by the time steers were shifted from one camp to another, is corroborated by the findings of Tribe (1952) who found that animals in great need readily consumed not only unpalatable material but even plants completely indigestible and even poisonous to them. It is also in accordance with the results of Hurd and Floyd (1958) who, in an investigation of the relative preference of species on summer cattle ranges in Wyoming, found that, by intensifying grazing pressure, greater utilization of the preferred species took place, but no change in preference.

The eager grazing of Aristida curvata seedheads appears to be correlated with its feeding value. In this respect, Henrici (1923), in an investigation of the phosphorus content of Bechuanaland grasses, found whole plants of Aristida and Tragus during seeding to contain three times as much phosphorus as whole plants of other grasses.

It appears contradictory that neither summer gains, spring losses, net gains, amount of liveweight maintained nor total digestible nutrients, under both severe and light grazing of either lime or dolomiteveld, were related to total annual rainfall. Reid (1957), working under Arizona conditions at the Santa Rita Experimental Range,

found.../70

found production of herbage to be highly variable and closely related to rainfall. He found herbage production to be, "840 pounds per acre in a favourable year as against 26 pounds per acre in a bad year."

It is highly improbable that such a large variation in the production of herbage between bad and good years, as instanced by Reid (1957), occurred in these experiments. Even if the grasses grew poorer in bad years, shrubs were always available to supplement the grasses, even during the worst seasons. Acocks (1939) considers these fodder trees and bushes a priceless asset, in that they are practically drought-proof.

On the other hand, it is possible that it was not so much the total amount of rainfall which influenced stock production as the amount of effective rain and its distribution over the growing season. The results obtained by Muirhead and McNeil (1956) in South Australia lend support to this view. These workers found the time of the first rains and their subsequent distribution to have had a direct bearing on the total weight and gain during the year.

Being grazed on a higher plane of nutrition enabled steers on lightly grazed veld, in comparison with steers on severely grazed veld, to put on more and to lose less weight and to end off seasons in better condition. Harlan (1958), at Illinois, found such a close relationship between stocking rate and animal gain that he propounded a mathematical formula for computing gains per acre from gain per head and stocking rate. Fischknecht, Harris and Woodward (1953) also arrived at a close relationship between intensity of stocking and average daily gain on crested wheatgrass. Semple and Hein (1942) at Beltsville, and Beetle, Johnson, Lang, May and Smith (1961) in north-central Wyoming, also found that heavy grazing reduced gains per steer but increased gains per acre, while for light grazing they found the reverse to apply. Huritt (1951) is of the opinion that, although subnormal liveweights and losses cannot be entirely avoided when drought prevails, observations made on the experimental range indicate

that.../71

that, through conservative stocking, weight losses can be minimized.

The slower gain in weight of steers on heavily grazed veld in comparison with that of steers on lightly grazed veld, at the commencement of the rainy season when light showers are frequent, might be ascribed to more vigorous grass tufts and longer leaves being produced faster in the case of light grazing treatments. Jantti and Kramer (1956) offer the same explanation. They showed that intact, transpiring plants absorbed water against a soil moisture tension of 15 atmospheres and more, in contrast with 1-2 atmospheres in defoliated plants.

The higher liveweight maintenance and appreciably more total digestible nutrients obtained from the six morgen grazing rates is due to steers grazing indiscriminately and browsing all plants more severely. Conversely, steers from the twelve morgen stocking intensities grazed and browsed the plants more selectively and less severely.

Steers grazing matured herbage with a higher fibre content under light stocking might have been responsible for the lower liveweight increment per morgen. In this connection Patton and Gieseker (1942) found that higher lignin content of crested wheatgrass led to lower daily gains. The lower summer gains per morgen from light grazing might also have been due to steers reaching their ceiling ability in per steer gains and suggests a heavier grazing rate at this time of the year.

The tendency for carcases coming from light grazing to grade better than those turned out by severe grazing is confirmed by Kincaid, Hunt and Litton (1958) at Virginia. They found carcase grade tended to improve as pasturage per steer increased. The higher prices realized by carcases of steers under light grazing in fact were a direct result of better grading. In this connection Black and Savage (1948) state, inter alia,"one fallacy of heavy grazing has been consistently demonstrated in the greatly reduced gains per head and lower market value of the cattle produced."

Per carcase, light stocking resulted in more beef being produced.

Conversely.../72

Conversely, severe grazing produced more beef per morgen, though of a poorer quality. The enhanced weight of beef produced per morgen did not compensate for the poorer grading and along with outright losses by death, led to a profit reduction of 86 and 77 cent per morgen respectively for lime and dolomite veld. The increase in the profit per morgen from light stocking is reflected in the higher rate of interest on capital invested. This amounts to light grazing exceeding severe grazing in rate of interest by more than four per cent per annum.

The five steers which were lost from severe grazing are in a large measure responsible for the poor profit and low rate of interest. In the event of the cost of replacement steers being ignored, the profit increases to 60 cent per morgen and the rate of interest rises to more than two per cent per annum.

The absence of Geigeria-poisoning, in spite of large numbers of Geigeria africana being present at times, lends support to the view that it is not so much the total population of this poisonous plant which is the cause of "vermoersiekte", but rather the proportion of this plant in relation to other ingested herbage. Throughout the experimental period there must have been a high proportion of non-toxic herbage available, and thus no animals died.

The main conclusion arrived at from this investigation is that fixed stocking rates are not justified in cases where summer weight gains are high and spring liveweight losses appreciable. A variable stocking, in numbers and in kind, with grazing as heavy as will maintain cattle in good condition, seems to be called for. Wehlen(1952) foresees the difficulty of balancing herbage production with stock consumption. He claims that, "The greatest single factor of instability in the exploitation of natural grasslands is their often extreme variation in seasonal production; this leads either to waste of fodder resources in the period of flush or to overstocking when the growth rate is low."

In the case of steers, a variable stocking rate will amount

to.../73

to marketing of older steers in late autumn and maintaining the younger steers at half the stocking rate through winter and spring. The author (Ebersöhn, 1961a) has shown that weaner-steers can be maintained exclusively on veld during winter, while steers a year older registered small losses. In grown-out steers winter liveweight loss became appreciable.

When rains set in in the next growing season, weaners will have to be acquired in order to double the winter and spring stocking rate. With cows calving down in December-January and calves being weaned at eight months, weaners should be freely available in September-October.

In the case of cows, a different system of balancing herbage production with stock consumption are called for. The writer (Ebersöhn, 1958) suggested that cows should be mated so that the last month of pregnancy and the first months of lactation (this being the period of maximal nutritional demand) should coincide with the six to seven month period of summer growth of herbage. Under this system cows run dry in late winter and spring. This system would synchronize the nutritional needs of the cow with the high productive capacity of veld in summer and autumn, and its maintenance capacity under light grazing in late-winter and spring.

During drought years an added refinement in adjusting the stocking rate will be necessary. Hurlitt's (1951) recommendations for the Northern Great Plains, whereby cows, heifers and steers are more severely culled and are marketed earlier, appear also to be worthy of consideration in years when herbage conditions on the Ghaap Plateau are unfavourable.

Veld improvement, in the sense that perennial grasses have increased in frequency, did not result from these grazing intensity experiments. It is considered that the veld reverted to a biotic subclimax under cattle grazing, a condition in which climax grasses are either maintained or decrease somewhat in abundance and seral grasses increase in frequency. This condition may prove to be reasonably stable and would appear to be as productive as the climax stage.

ANNEXURE 1.../74

ANNEXURE 1.

THE CONVERSION OF LIVEWEIGHT MAINTAINED, GAINED OR LOST INTO TOTAL DIGESTIBLE NUTRIENTS. (T.D.N.)

According to Nevens (1945), liveweight maintained per unit area is an essential additional measure of gain or loss. "It occurred that little or no liveweight gains were made by animals even when the pasture was heavily stocked with either young or mature cattle. Yet the pasture may provide large amounts of feed which serves as a maintenance ration." He proposed the calculation for liveweight maintenance per acre to be

$$\frac{\text{Average weight of animals} \times \text{Days on pasture}}{\text{Number of acres per animal.}}$$

The factor for converting liveweight maintenance into total digestible nutrients for maintenance was calculated by Nevens (1945) from the maintenance requirements of 750-pound heifers and was estimated to be 7.76 pounds of T.D.N. daily per one thousand pound liveweight. Niemann (1961), in a personal communication, suggested that the factor for maintenance could be linearly calculated from the maintenance requirements of 750-pound heifers and arrived at a factor of 8.2 pound T.D.N. daily per one thousand pounds liveweight. This is based on the latest feeding standards of Morrison (1957) whereby a 750-pound metabolic weight heifer needs 6.18 pounds T.D.N. daily for maintenance.

The average bodyweight during each unbroken period on the veld was used to estimate the T.D.N. requirements for maintenance during that period. This conforms with the practice followed by Brundage, Swectman, Hodgson and Bula (1956).

It is realized that the factor for maintenance should have been arrived at curvo-linearly, rising from 750 pounds to 1000 pounds and more. But because closely matched groups of animals, with liveweights varying between 500 and 1200 pounds, were used in the experiments and because the T.D.N. figures obtained will not be used in an absolute sense but only comparatively, the additional effort involved

would.../75

would not be compensated for by the extra preciseness gained. Reid et al, quoted by Huffman (1959), are of the opinion that cattle under range conditions require 40 per cent more T.D.N. for maintenance as compared to stall-fed animals. Adding 40 per cent to the factor of 8.2 already arrived at, resulted in a final estimate of 11.48 pounds T.D.N. daily requirement per 1000 pound liveweight.

Knott, Hodgson and Ellington (1934), in employing the energy content of protein and fat in animal gain, arrived at a figure of 3.53 pound T.D.N. for each pound gain in bodyweight of dairy cattle. Mosely, Stuart and Graves (1927) arrived at a figure of 4.3 pound T.D.N. for each pound of gain for fattening steers. Since there is a closer resemblance between the gains of steers on veld grazing and gains in dairy cows than there is between either of these and steers being rapidly fattened, the factor of 3.53 was preferred.

Allowance for loss in liveweight is more difficult to make. Some investigators use the same amount of T.D.N. for correcting either gain or loss in liveweight. Knott, Hodgson and Ellington (1934) prefer a lower figure, again estimated from the requirements of dairy cattle, of 2.73 pounds T.D.N. for every pound of loss in bodyweight.

T.D.N. requirements for maintenance, gain and loss in liveweight of sheep are not at all as well investigated as in the case of cattle. Regarding the efficiency of farm animals in the conversion of feeding stuffs, Leitch and Goddon (1953) state that, "It has not been possible to make an extensive study of mutton and lamb production since so much of the life of the sheep is spent on pasture and it is impossible to estimate either the consumption of grass or its feeding value. Apart from a slightly higher efficiency of protein conversion, there is little difference between the lamb and the bullock."

Following on this, the T.D.N. requirements for producing one pound of bodyweight in sheep was taken as 3.53 pound and 2.73 pound T.D.N. was taken for every pound loss in bodyweight. Similarly, for the daily maintenance requirement of sheep with a bodyweight of

100.../76

100 pounds, 1.148 pound T.D.N. was used. This is in close agreement with the factor of 1.1 pound T.D.N. for maintenance per 100 pounds bodyweight requirement mentioned by Starke (1946) and quoted by him as having been used by Smuts and Harris.

ANNEXURE 2.

GAINS, LOSSES AND MAINTENANCE OF LIVEWEIGHT IN LB. T.D.N. ON LIMPVELD AND CONTRIBUTION OF THESE FACTORS TO T.D.N. OBTAINED PER MORGEN.

Seasons.	Rainfall (mm.)	Expt. 10 L – (12 morgen/steer) Liveweight maintained	Gains	T.D.N.	Loss	Net T.D.N.	Expt. 11 L. (6 morgen/steer). Liveweight maintained	Gains	T.D.N.	Loss.	Net T.D.N.
1948/49	151	330	79	409	23	386	502	109	611	71	540
1949/50	588	433	139	572	37	535	682	234	916	87	829
1950/51	470	243	66	309	5	304	449	113	562	24	538
1951/52	288	280	85	365	43	322	427	102	529	49	480
1952/53	418	259	102	361	30	331	388	97	485	83	402
1953/54	378	270	123	393	20	373	344	190	534	43	491
1954/55	459	281	78	359	34	325	227	101	328	60	268
1955/56	563	286	100	386	18	368	524	158	682	20	662
1956/57	427	299	99	398	19	379	567	131	698	40	658
Mean per season.	419	297	97	394	25	369	453	137	590	49	541
Per cent	–	75	25	100	6	94	77	23	100	8	92

ANNEXURE 3.

GAINS, LOSSES AND MAINTENANCE OF LIVEWEIGHT IN LBS. T.D.N. ON DOLOMITEVELD AND CONTRIBUTION OF THESE FACTORS TO T.D.N. OBTAINED PER MORGEN.

Seasons.	Rainfall (mm.)	Expt. 10 D – (12 morgen per steer): Liveweight maintained	Gains	T.D.N.	Loss	Net T.D.N.	Expt. 11 D – (6 morgen per steer): Liveweight maintained	Gains	T.D.N.	Loss	Net T.D.N.
1948/49	151	311	64	375	32	343	498	90	588	65	523
1949/50	588	407	138	545	32	513	686	243	929	94	835
1950/51	470	407	86	493	19	474	462	127	589	38	551
1951/52	288	291	67	358	30	328	499	112	611	102	509
1952/53	418	300	111	411	23	388	497	153	650	80	570
1953/54	378	285	123	408	25	383	499	225	724	92	632
1954/55	459	274	71	345	33	312	473	115	588	90	498
1955/56	563	284	94	378	8	370	428	181	609	41	568
1956/57	427	295	91	386	19	367	508	157	665	60	605
Mean per season.	419	317	94	411	25	386	506	157	663	75	588
Per cent.	–	77	23	100	6	94	76	24	100	11	89

B.../79

B. GRAZING SYSTEMS.

These experiments were initiated in October 1944 and were terminated in July 1953. They were all conducted on both lime and dolomiteveld. This data formed part of the material of a thesis submitted by the author to the University of the Witwatersrand for the degree of Master of Science in the Botany Department. Table XVIII gives details of the six grazing system experiments.

TABLE XVIII.

GRAZING SYSTEMS WITH CATTLE ON VELD.

Experiment No.	Particulars.
6 L.	Limeveld: System III - 3 steers to 24 morgen.
7 L.	: System IV - 3 steers to 24 morgen.
8 L.	: System V - 6 steers to 48 morgen.
6 D.	Dolomiteveld: System III - 3 steers to 24 morgen.
7 D.	: System IV - 3 steers to 24 morgen.
8 D.	: System V - 6 steers to 48 morgen.

Veld and steer interaction was measured by means of

(1) Frequency estimates of plants,
(2) Field observations,
(3) Soil analysis,
(4) Liveweight changes, deaths and departure from systems,
(5) Liveweight-curve area,
(6) Slaughter details, and
(7) Geigeria-poisoning.

(1) PLANT FREQUENCY ESTIMATES:

In Tables XIX and XX the change in the number of plants per quadrat during the experimental period is given for lime and dolomiteveld respectively.

TABLE XIX.../80

TABLE XIX.

PLANT RESPONSE TO THREE GRAZING SYSTEMS WITH CATTLE ON LIMEVELD AT KOOPMANSFONTEIN.

	Number of plants in 15 quadrats (s)					
	Expt. 6 L. System III		Expt. 7 L. System IV		Expt. 8 L. System V	
	1947	1953	1947	1953	1947	1953
CLIMAX SPECIES:						
Themeda triandra	19	23	16	16	13	8
Fingerhuthia africana	49	8	44	5	49	6
Panicum coloratum	0	0	0	0	1	4
Chrysopogon montanus	18	17	4	5	34	11
Sporobolus fimbriatus	12	5	0	10	15	10
Eustachys paspaloides	9	1	9	0	1	0
Digitaria eriantha	44	2	14	2	13	10
Cymbopogon plurinodis	10	13	14	8	25	60
Aristida vestita	6	2	0	0	4	3
Heteropogon contortus	2	0	0	0	2	5
Sub-total	169	71	101	46	157	117
SERAL SPECIES:						
Eragrostis lehmanniana	42	105	150	174	109	212
Tragus koelerioides	49	0	60	3	38	1
Sub-total	91	105	210	177	147	213
PIONEER SPECIES:						
Enneapogon brachystachyus	197	652	94	937	179	999
Tragus racemosus	80	307	14	483	1	440
Aristida curvata	126	58	0	5	19	24
Oropetium capense	0	61	0	12	0	6
Sub-total	403	1078	108	1437	199	1469
WEEDS:						
Geigeria africana	1	191	3	188	7	132
Tribulus terrestris	2	35	36	59	30	23
Chrysocoma tenuifolia	3	5	5	27	6	14
Sub-total	6	231	44	274	43	169
KARROID SPECIES:						
Monechma divaricatum	3	13	3	8	3	11
Aster muricatus	3	9	1	18	4	27
Indigofera patens	0	5	0	6	0	6
Sub-total	6	27	4	32	7	44
OTHER SPECIES:						
Woody	1	7	1	0	0	4
Herbaceous	40	72	68	138	32	50
Sub-total	41	79	69	138	32	54
GRAND TOTAL	716	1491	536	2104	585	2066

Woody species comprise the genera Rhus, Euclea, Maytenus, Tarchonanthus and Asparagus.

Herbaceous species comprise the genera Barleria, Commelina, Stachys, Pharnaceum, Limeum, Scilla, Sericorema, Hibiscus, Atriplex, Hermannia, Sutera, Cyperus and Corchorus.

(s) = Surveys according to the method of Raunkiaer as described by Murray (1946).

TABLE XX.../81

TABLE XX.

PLANT RESPONSE TO THREE GRAZING SYSTEMS WITH CATTLE ON DOLOMITEVELD AT KOOPMANSFONTEIN.

	Number of Plants in 15 Quadrats (s)					
	Expt. 6 D. System III		Expt. 7 D. System IV		Expt. 8 D. System V	
CLIMAX SPECIES:	1947	1953	1947	1953	1947	1953
Themeda triandra	0	7	1	5	11	13
Fingerhuthia africana	8	2	0	0	0	0
Panicum coloratum	0	17	0	0	0	0
Chrysopogon montanus	22	26	8	11	0	0
Sporobolus fimbriatus	5	11	1	1	0	0
Eustachys paspaloides	2	0	0	0	4	2
Digitaria eriantha	57	33	58	25	78	123
Cymbopogon plurinodis	3	7	0	0	0	0
Enneapogon scoparius	7	2	105	0	10	0
Heteropogon contortus	17	0	1	0	12	40
Sub-Total	117	105	174	42	115	173
SERAL SPECIES:						
Eragrostis lehmanniana	91	448	191	168	55	480
E. denudata	71	51	202	47	86	88
Tragus koelerioides	15	0	20	0	1	0
Sub-Total	177	499	413	215	142	568
PIONEER SPECIES:						
Enneapogon brachystachyus	66	201	0	404	6	144
Tragus racemosus	44	536	58	425	53	139
Aristida curvata	29	13	28	54	81	63
Oropetium capense	0	139	0	342	0	253
Sub-Total	139	889	86	1225	140	599
WEEDS						
Geigeria africana	0	7	2	82	1	3
Tribulus terrestris	18	24	7	29	4	10
Chrysocoma tenuifolia	8	6	8	8	1	1
Ornithoglossum glaucum	1	2	0	0	0	0
Sub-Total	27	39	17	119	6	14
KARROID SPECIES:						
Monechma divaricatum	0	0	0	0	2	1
Aster muricatus	2	5	0	8	0	0
Indigofera patens	0	0	0	0	1	2
Sub-Total	2	5	0	8	3	3
OTHER SPECIES:						
Woody	3	8	6	7	8	23
Herbaceous	22	62	19	93	7	39
Sub-Total	25	70	25	100	15	62
GRAND TOTAL	487	1607	715	1709	421	1419

Woody species comprise the genera Asparagus, Euclea, Maytenus and Rhus.
Herbaceous species comprise the genera Commelina, Limeum, Hibicus, Cyperus, Scilla, Sericorema, Atriplex, Hermannia, Sesamum, Monsonia, Corchorus and Stachys.

(s) = Surveys according to that of Raunkiaer as described by Murray (1946).

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The method of plant counts was inadequate in that quadrats were too small, replications too few and the initial counts undertaken too late. Because of these shortcomings, large changes only in the number of species will be considered.

Under all systems, Themeda triandra, Chrysopogon montanus, Sporobolus fimbriatus and Cymbopogon plurinodis on both veld types and Digitaria eriantha on dolomiteveld and under system V on lime, stood up to cattle grazing. Conditions under system V appear to favour the increase of Heteropogon contortus on dolomite and Cymbopogon plurinodis on lime. Fingerhuthia africana and Eustachys paspaloides, neither on lime nor on dolomite, were able to tolerate cattle grazing.

The incidence of climax species decreased except under system V on both veld types and under system III on dolomite. Seral species (except under continous grazing), pioneers, herbs, weeds and karroid species, particularly on lime, increased between counts. The largest number of Chrysocoma tenuifolia, at the end of the experimental period, occurred under continuously grazed lime and dolomiteveld. On dolomite the population of karroid species remained reasonably stable while it increased on limeveld.

Owing to pronounced seasonal variation in the occurrence of Geigeria africana, no deductions from the counts of two isolated seasons are justified.

(2) FIELD OBSERVATIONS:

Eragrostis lehmanniana, Fingerhuthia africana, Digitaria eriantha and Themeda triandra were preferred by cattle above all other grasses. Cymbopogon plurinodis, Heteropogon contortus and Aristida vestita were grazed only when young. Enneapogon scoparius was favoured when its seeds were ripening.

In late winter, with grasses cropped short, steers took to browsing the shrubs. Larchonanthus minor was particularly sought after, and was observed to be slow in recovering after a drought. Continuous grazing forced steers to commence browsing as early as

autumn.../83

autumn, and to continue right up to the occurrence of the first rains. The annual recurrence of such long-continued use caused the ground around the bushes to be severely trampled. In the same process twigs and thick branches also were broken off. Steers always preferred grasses to shrubs, when grasses were available; and it was immaterial whether the grasses were green or dry. At the emergence of the first new blades of grass, usually annuals, steers left off browsing the shrubs and concentrated on the new growth.

Under continuous grazing the number of grasses, especially Digitaria and Eustachys on lime and Enneapogon scoparius on dolomite, dying from the centre of the tufts, were considerable. Grasses became dwarfed in stature and species favoured by steers were prevented from seeding.

Grass tufts in camps receiving a full-summer rest followed by autumn and early-winter grazing, sprouted more vigorously in spring than tufts in camps exposed to all-summer grazing, followed by autumn and winter resting. Eragrostis lehmanniana was the first grass to turn green in spring, followed by Cymbopogon, Chrysopogon, Themeda and other grasses and shrubs.

In camps under split-summer system V, maturation of grasses was retarded and short, leafy herbage was available well into winter. Where camps were subjected to full-summer rest grasses matured early and the resulting herbage proved less acceptable to steers throughout winter.

When abundant rains succeeded a severe drought, as happened in 1950 and 1953, Aristida curvata constituted the principal pioneer grass and the first herbage available. In normal rainfall seasons Enneapogon brachystachyus and Eragrus racemosus were prominent as the main pioneers. Grazing of camps in early summer prevented A. curvata from running to seed.

Tuft grasses occupied the ground unevenly in the case of continuous grazing on both veld types and also under the three-camp system on lime. In fact, they were almost wholly confined to cracks, in

among.../84

among rocks and under the shrubs. In turn, annual grasses, weeds and other herbaceous growth predominated, and in some cases occupied, almost exclusively, the deeper soil in pans and low-lying areas.

(3) SOIL ANALYSIS:

In Tables XXI and XXII particulars are given of physical and chemical analyses of soils, derived from experiments on lime and dolomiteveld respectively, which had been exposed to the different grazing systems for the duration of these experiments.

TABLE XXI.../85

TABLE XXI.

MECHANICAL AND CHEMICAL ANALYSES(s) OF LIMEVELD SOILS UNDER THREE GRAZING SYSTEMS WITH CATTLE AT KOOPMANSFONTEIN.

Soil horizon (inches)	Expt.6L-Syst.III			Expt.7L-Syst.IV			Expt.8L-Syst.V		
	0-3	3-6	6-12	0-3	3-6	6-12	0-3	3-6	6-12
pH.	7.23	7.14	6.87	7.32	6.92	6.79	7.43	7.57	7.58
Resistance at 60°F.	1380	1380	1280	1150	1120	1100	1340	1250	1050
Mechanical analysis:(%):									
Sand(> 0.02 mm.)	82.49	84.12	78.14	81.61	79.90	79.47	79.45	74.39	70.27
Silt(0.02-0.002 mm.)	6.16	5.56	4.50	6.78	5.60	4.71	8.66	12.73	15.18
Clay(<0.02 mm.)	11.53	10.32	17.36	11.61	14.50	15.82	11.89	12.88	14.55
$CaCO_3$(%).	0.00	0.00	0.00	0.07	0.00	0.00	2.99	3.97	6.80
P.(%)(z)	.0018	.0014	.0004	.0025	.0008	.0007	.0030	.0024	.0019
C.(%)	1.17	0.96	0.71	1.20	0.87	0.66	0.92	1.04	0.98
N.(%)	0.10	0.10	0.06	0.13	0.09	0.05	0.11	0.11	0.08
C : N ratio.	11.4:1	9.2:1	12.0:1	9.2:1	10.1:1	12.9:1	8.4:1	9.5:1	12.4:1
Water-soluble salts(%)(n):									
Na.	.0009	.0011	.0010	.0010	.0010	.0009	.0007	.0007	.0009
K.	.0017	.0017	.0017	.0011	.0005	.0004	.0017	.0010	.0005
Ca.	.0035	.0033	.0028	.0059	.0035	.0024	.0057	.0063	.0061
Mg.	.0004	.0003	.0004	.0006	.0002	.0005	.0003	.0005	.0007
HCO_3.	.0101	.0095	.0086	.0183	.0103	.0068	.0185	.0200	.0187
Cl.	.0035	.0030	.0030	.0024	.0024	.0030	.0021	.0027	.0024

(s) = Analyses by D.F.M. Claassen.

(z) = 1% Citric acid solution.

(n) = Soil : Water :: 1 : 2.

With increasing depth of soil, there is no difference in the tendencies between systems III and IV; but the silt fraction from system V increases with increasing depth of soil and is higher with a correspondingly lower sand fraction compared with a decrease in the case of systems III and IV. Under system V the phosphorus

status.../86

status of soils from all horizons is higher than that of soils under either of the other two systems. In the 0-3 inch horizon, the carbon-nitrogen ratio of soil under system V is narrower than that of the other two systems.

TABLE XXII.../87

TABLE XXII.

MECHANICAL AND CHEMICAL ANALYSES(s) OF DOLOMITE SOILS UNDER THREE GRAZING SYSTEMS WITH CATTLE AT KOOPMANSFONTEIN.

Soil horizon (inchos)	Expt.6 D-Syst.III.			Expt.7 D-Syst.IV			Expt.8 D-Syst.V.		
	0-3	3-6	6-12	0-3	3-6	6-12	0-3	3-6	6-12
pH.	7.50	7.52	7.42	7.58	7.48	7.68	6.98	7.18	7.49
Resistance at 60°F.	1000	1450	1360	1230	1220	930	1390	1060	1250
Mechanical analysis:(%):									
Sand(> 0.02 mm.)	82.32	81.71	82.29	79.79	79.82	82.86	81.42	81.96	82.67
Silt(0.02-0.002 mm.)	5.86	6.30	6.20	6.83	6.68	4.48	8.02	6.81	7.53
Clay(<0.002 mm.)	11.82	11.99	11.51	13.38	13.50	12.66	10.56	11.23	9.80
$CaCO_3$.(%)	0.04	0.00	0.00	0.81	0.00	0.06	0.00	0.00	0.00
P.(%)(z)	.0027	.0016	.0021	.0022	.0009	.0017	.0020	.0014	.0049
C.(%)	0.84	0.95	1.37	0.86	0.86	0.87	0.74	0.63	1.04
N.(%)	0.10	0.10	0.14	0.10	0.08	0.08	0.09	0.07	0.10
C : N ratio.	8.2:1	9.7:1	10.1:1	8.8:1	10.2:1	10.6:1	8.3:1	8.8:1	10.1:1
Water-soluble salts(%)(n).									
Na.	.0016	.0012	.0010	.0010	.0011	.0009	.0007	.0008	.0009
K.	.0006	.0008	.0017	.0010	.0004	.0003	.0008	.0003	.0003
Ca.	.0055	.0041	.0054	.0046	.0039	.0035	.0035	.0035	.0055
Mg.	.0007	.0012	.0005	.0005	.0010	.0005	.0002	.0005	.0004
HCO_3.	.0169	.0142	.0146	.0139	.0136	.0156	.0100	.0107	.0162
Cl.	.0027	.0027	.0027	.0030	.0030	.0032	.0032	.0030	.0035

(s) = Analyses by D.F.M. Claasen.

(z) = 1% Citric acid solution.

(n) = Soil : Water :: 1 : 2.

There is no difference in the depth tendencies of soils under systems III and IV, but under system V the sodium content of the soil increases with increasing depth whilst it decreases with increasing depth in the case of system III. Soil under system IV

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has the lowest phosphorus status for all horizons with system V soils the highest status. The clay fraction for all horizons under system V is the lowest while its silt fraction is the highest of all three systems.

(4) LIVEWEIGHTS:

In Tables XXIII and XXIV the average liveweight gains and losses, liveweight maintained and total digestible nutrients obtained are given for steers grazing lime and dolomiteveld under three grazing systems.

TABLE XXII'.../89.

TABLE XXIII

LIVEWEIGHT GAINS AND LOSSES PER STEER(n) AND LIVEWEIGHT MAINTAINED AND T.D.N. OBTAINED IN POUNDS PER MORGEN ON LIEVELD.

Seasons.	Total rainfall (m.m.).	Expt. 6 L – Three camp system. Gains	Losses	Net Gain	Liveweight maintained per morgen	T.D.N. per morgen	Expt. 7 L – Continuous grazing. Gains	Losses	Net Gain	Liveweight maintained per morgen	T.D.N. per morgen	Expt. 8 L – Five camp, Two herd system. Gains	Losses	Net Gain	Liveweight maintained per morgen	T.D.N. per morgen.
1944/45	255	357	187	170	47149	636	362	242	120	49309	751	374	281	93	45721	569
1945/46	268	414	322	92	62053	779	456	283	173	64652	847	367	296	71	51985	715
1946/47	300	95	52	43	18743	239	104	109	-5 (x^9)	17923	215	100	79	21	17923	223
1947/48	466	384	101	273	36034	549	449	132	317	36119	568	340	97	243	33420	501
1948/49	151	212	137	85 (x^5)	38238	485	277	214	53 (x^5)	37153	476	232	161	71 (x^6)	34509	443
1949/50	538	558	197	361	52875	786	571	137	434	54675	832	481	141	340	49540	731
1950/51	470	210	53	157	31189	432	218	62	156 (x^9)	31437	436	213	99	114	30539	409
1951/52	288	209	162	47	35640	446	215	192	23	33720	417	246	186	60	35230	450
1952/53	418	333	126	207	34489	500	310	125	185	32120	463	312	141	171	34039	480
Mean/season	356	308	149	159	–	–	329	166	163	–	–	296	159	137	–	–
Mean/season/morgen.	–	39	19	20	39601	539	41	21	20	39679	556	37	20	–	37551	503

(v) = Digression from system.

(x^2) = Steers removed from 10.12.47 to 23.12.47 due to no herbage being available.

(x^5) = Steers removed from 26.10.49 to 10.1.50 due to no herbage being available.

(x^6) = Steers removed from 8.11.49 to 10.1.50 due to no herbage being available.

(x^9) = Steers removed from 17.1.52 to 12.2.52 due to no herbage being available.

(n) = Weights given are the mean of three steers.

TABLE XXIV.

LIVEWEIGHT GAINS AND LOSSES PER STEER(n) : LIVEWEIGHT MAINTAINED AND T.D.N. OBTAINED IN POUNDS PER MORGEN ON DOLOMITEVELD.

Seasons.	Total rainfall (m.m.).	Expt. 6 D - Three camp system. Gains	Losses	Net Gain	Liveweight maintained per morgen	T.D.N. per morgen	Expt. 7 D - Continuous grazing. Gains	Losses	Net Gain	Liveweight maintained per morgen	T.D.N. per morgen	Expt. 8 D - Five camp, two herd system. Gains	Losses	Net Gain	Liveweight maintained per morgen	T.D.N. per morgen
1944/45	255	418	285	133	47856	636	356	303	53	53669	670	433	255	178	50293	644
1945/46	268	386	176	210	59541	759	451	283	168 (vx)	64434	842	454	303	151	64489	879
1946/47	300	70	67	3	17609	210	47	86	-39	16916	186	108	80	28	36352	229
1947/48	466	382	64	318 (vx^6)	34171	538	432	99	333 (vx^3)	35035	558	411	87	324 (vx^5)	36104	566
1948/49	151	271	201	70	39663	506	107	177	-70	30481	337	245	162	83	37519	484
1949/50	588	439	155	284	59985	829	500	124	376	49635	748	503	135	368	53482	791
1950/51	470	222	75	147 (v)	30857	426	232	76	156 (vx^8)	30887	431	211	55	156 (v)	32183	444
1951/52	288	248	188	60	34440	440	284	214	70	33360	435	224	192	32	34688	431
1952/53	418	369	99	270	37711	561	312	153	159	35924	490	322	96	126	35436	515
Mean/season	356	312	146	166	-	-	302	168	134	-	-	324	152	172	-	-
Mean/season/morgen.	-	39	18	21	40215	545	38	21	17	38927	522	41	19	22	40263	554

(v) = Digression from system.

(x) = Steers removed from 11.11.47 to 23.12.47 due to no herbage being available.

(x^3) = Steers removed from 1.10.49 to 10.1.50 due to no herbage being available.

(x^5) = Steers removed from 26.10.49 to 10.1.50 due to no herbage being available.

(x^6) = Steers removed from 8.11.49 to 10.1.50 due to no herbage being available.

(x^8) = Steers removed from 18.12.51 to 12.2.52 due to no herbage being available.

(n) = Weights given are the mean of three steers.

As regards livestock reaction there is little to choose between the different grazing systems. On lime, continuous grazing excelled by a small margin while the five-camp system proved best on dolomiteveld. Continuous grazing was responsible for the largest liveweight loss in spring.

There appear to be no correlation between the total rainfall during any particular season, on the one hand, and liveweight gains and losses, total digestible nutrients or liveweight maintenance on the other hand. No evidence exists indicating either a diminution or an increase in livestock production over the nine years.

The respective systems did not materially differ in the manner in which total digestible nutrients were divided among gains, losses and maintenance. On an average, 77 per cent of the total digestible nutrients were used towards maintenance. Of the 23 per cent that went into liveweight gain, 9 per cent was lost again in spring.

None of the systems could provide for stock in the 1949 drought and continuous grazing failed a second time in 1947 and 1952, in early summer. Steers were removed from the experiments for lengthy periods. This was resorted to in order to prevent them dying from poverty which occurred in three out of nine seasons in the case of continuous grazing and once with each of the camp systems.

(5) LIVEWEIGHT-CURVE AREA:

In Tables XXV and XXVI the area of the liveweight curve of matched pairs of three steers, for lime and dolomiteveld respectively, together with levels of significant differences between areas, are given.

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TABLE XXV.

AREA BELOW THE LIVEWEIGHT-CURVE OF STEERS GRAZING LUCERNE UNDER THREE GRAZING SYSTEMS.

Period on Experiment.	Expt. 6 L – System III Steer No.	Area.	Expt. 7 L – System IV Steer No.	Area.	Expt. 8 L – System V Steer No.	Area.
31.10.44. to 15.4.47.	3	37345	5	40567	17	39332
31.10.44. to 15.4.47.	4	42957	6	44572	18	42545
5.2.46. to 15.4.47.	227	12977	157	12855	219	12583
16.4.47. to 5.1.51.	2439	52707	2348	51221	2378	43368
16.4.47. to 14.8.51.	2528	45006	2512	53672	2415	52427
16.4.47. to 1.7.52.	2403	63519	2583	63704	2331	62780
6.1.51. to 15.7.53.	E.22	30156	E.4	24222	E.43	27630
15.8.51. to 15.7.53	E. 3	14773	E.5	15148	E.44	16977
2.7.52. to 15.7.53.	E. 1	7022	E.6	6553	E.40	5123

(s) = A pair of steers was used in this experiment as against single steers in the case of Experiments 6 L and 7 L. The steer whose liveweight at commencement of period closest approached those of its pairs in experiments 6 L and 7 L, was used for area calculation.

* = H-requirement = 9.21 at P=0.010 (2 D.F.)

(n) = Values given for this period are Mann-Whitney "U" values and probabilities are from Siegel's (1956) K-tables, $n_1=n_2=14$.

N.S. = Not significant.

TABLE XXV.

LUCERNE UNDER THREE GRAZING SYSTEMS.

Period on Experiment.	H	Calculated values of z: 6L/7L	7L/8L	6L/8L	Calculated values of p: 6L/7L	7L/8L	6L/8L	Significant Differences: P ≤ 0.010.
31.10.44. to 15.4.47.	9.06	–	–	–	–	–	–	N.S.
31.10.44. to 15.4.47.	1.47	–	–	–	–	–	–	N.S.
5.2.46. to 15.4.47.	2.26	–	–	–	–	–	–	N.S.
16.4.47. to 5.1.51.	15.27	1.32	2.76	3.19	0.093	0.003	<0.001	6L; 7L > 8L
16.4.47. to 14.8.51.	18.81	1.80	0.66	1.24	0.036	0.255	0.108	N.S.
16.4.47. to 1.7.52.	1.71	–	–	–	–	–	–	N.S.
6.1.51. to 15.7.53.	36.52	5.92	3.29	3.79	<0.001	<0.001	<0.001	6L > 8L > 7L
15.8.51. to 15.7.53	8.80	–	–	–	–	–	–	N.S.
2.7.52. to 15.7.53.	18.63	55(n)	33(n)	12.5(n)	0.05 (n)	>0.002 (n)	<0.002 (n)	6L; 7L > 8L

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TABLE XXVI

AREA BELOW THE LIVEWEIGHT-CURVE OF STEERS GRAZING DOLOMITEVELD UNDER THREE GRAZING SYSTEMS.

Period on Experiment.	Expt. 6 D – System III Steer No.	Area.	Expt. 7 D – System IV Steer No.	Area.	Expt. 8 D – System V (a) Steer No.	Area.	Calculated values of z: H*	6D/7D	7D/8D	6D/8D	Calculated values of p: 6D/7D	7D/8D	6D/8D	Significant Differences P ≤ 0.010
31.10.44. to 15.4.47.	7	35793	10	46160	12	46745	32.06	4.91	0.42	4.90	<0.001	0.337	<0.001	7D>6D<8D
31.10.44. to 15.4.47.	8	44250	9	45005	13	44672	0.58	–	–	–	–	–	–	N.S.
5.2.46. to 15.4.47.	120	11817	43	11041	151	12692	14.38	2.35	1.41	2.07	0.009	0.079	0.019	6D>7D.
16.4.47. to 5.1.51.	2543	43043	2452	42823	2447	47728	7.73	–	–	–	–	–	–	N.S.
16.4.47. to 14.8.51.	2386	57866	2411	48901	2451	56883	9.24	2.46	2.62	0.11	0.007	0.004	0.456	6D; 8D>7D
16.4.47. to 1.7.52.	2324	60222	2547	63489	2502	64562	5.11	–	–	–	–	–	–	N.S.
6.1.51. to 15.7.53.	E.19	29707	E.11	28688	E.35	37978	7.23	–	–	–	–	–	–	N.S.
15.8.51. to 15.7.53.	E. 8	16594	E.10	14251	E.36	16612	4.12	–	–	–	–	–	–	N.S.
2.7.52. to 15.7.53.	E. 7	7718	180	6720	E.34	6984	9.85	43.5 (n)	71.5 (n)	47 (n)	>0.02	>0.10	0.02	N.S.

(a) = A pair of steers was used in this experiment as against single steers in the case of Experiments 6 D and 7 D. The steer whose liveweight at commencement of periods closest approached those of its pairs in experiments 6 D and 7 D, was used.

* = H-requirement = 9.21 at P=0.010 (2 D.F.)

(n) = Values given for this period are Mann-Whitney "U" values and probabilities are from Siegel's (1956) K-tables, $n_1 = n_2 = 14$.

N.S. = Not significant.

(6) SLAUGHTERINGS:

In Table XXVII particulars are given of slaughterings, capital investment, profit and rate of interest for the different grazing systems on lime and dolomiteveld respectively.

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TABLE XXVII.

SLAUGHTER PARTICULARS(n) AND FINANCIAL RETURNS(z) OF STEERS UNDER THREE GRAZING SYSTEMS AT KOOPMANSFONTEIN.

	Limeveld.			Lolmiteveld.		
	Expt. 6 L	Expt. 7 L	Expt. 8 L	Expt. 6 D	Expt. 7 D	Expt. 8 D
	Syst. III	Syst. IV	Syst. V	Syst. III	Syst. IV	Syst. V
Farm liveweight in lb.	1156	1118	1071	1143	1089	1146
Warm carcase-weight in lb.	606	610	576	640	586	624
Dressing Percentage.	52	55	54	56	54	55
Grade.	I	I	I	I	I	I
Capital investment.						
Land at R12 per morgen.	R288	288	576	288	288	576
Steers at R24 each.	R144	144	288	144	144	288
Licks and Inoculations.	R 36	36	72	36	36	72
Total capital investment.	R468	468	936	468	468	936
Gross return from steers over 5 years.	R282	271.2	516.6	283.6	265.4	568.2
Less stock expenditure.	R180	180	360	180	180	360
Excess of gross return over stock expenditure.	R102	91.2	156.6	103.6	85.4	208.2
Area of expts. in morgen.	24	24	48	24	24	48
Profit per morgen per year.	86c	76c	65c	36c	71c	87c
Rate of interest per annum.	4.4%	3.9%	3.3%	4.4%	3.7%	4.5%

(n) = Particulars are the mean of 6 steers in the case of Expts. 6 L, 7 L, 6 D and 7 D, and of 12 steers in the case of Expts. 8 L and 8 D.

(z) = Financial particulars are the total for every experiment.

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The five-camp system on lime and continuous grazing on dolomite resulted in the lightest carcases, the poorest profit and the lowest return on capital. In general, there is little to choose between systems and veld types, but the three-camp system on lime and the three and five-camp systems on dolomite yielded the most favourable results.

(7) GEIGERIA-POISONING.

No cases of "vermeersiekte" nor any other deaths occurred on any of the experiments.

DISCUSSION:

The reaction of the veld to use by cattle under different grazing systems was essentially similar to that obtained under different grazing intensities described earlier. Themeda, Cymbopogon, Chrysopogon and Digitaria criantha were again tolerant to grazing, while Fingerhuthia and Tragus koelerioides proved intolerant to grazing by cattle. The same tendency of a decline in climax species, except for Digitaria on dolomite, and the higher incidence of seral, pioneer, karroid and herbaceous species evidenced in the grazing intensity experiments, is obvious here. This suggests a rearrangement of the constituent species of the sward towards a biotic sub-climax under cattle grazing.

The various grazing systems, in spite of their diversity regarding the respective length and season of grazing and resting, differed little in their effect on the veld. In this connection there is disagreement among other investigators. Some found rotational grazing to benefit the veld. Others again found continuous grazing superior to grazing systems in this respect.

Trumble (1949), working with cultivated pastures under dryland conditions in South Australia, found that continuous grazing was not disadvantageous, provided, "a sufficiency of photosynthesising leaf surface of the species most desired in the pasture is maintained." He affirms the need for the mowing machine and adjustment of stocking

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rates according to seasonal growth conditions. He further emphasizes that neither rate nor system of grazing can be planned on a rigid basis because of their dependence on circumstances that are unpredictable.

Pasture investigations conducted by the Commonwealth Scientific and Industrial Research Organisation in Western Australia (Anonymous, 1960), showed that Hyparrhenia hirta, a desirable species under those conditions, withstood continuous grazing. Davidson, Phillip and Donald, quoted by Donald and Black (1958), pointed out that rotational grazing appears to offer no advantage over continuous grazing in regard to holding a pasture at the optimum leaf area index; "provided the stock density is just sufficient to remove the feed as produced, continuous grazing will give maximum pasture production." Pasture research workers at Potchefstroom on the Transvaal Highveld (Anonymous, 1958) found that under continuous grazing the basal area of plants was reduced while that of rotationally grazed plants remained constant.

Aldrich (1959) suggests that the greatest disadvantage of continuous grazing is the repeated defoliation of the most palatable species and root depletion, and that these processes eventually result in the disappearance of the preferred species.

Kumar and Godbole (1933) found improvement in both quality and quantity of grass in the adoption of a system of intermittent intensive grazing in Western India. These workers found camps helped to establish grass, which under continuous use would have been trampled, uprooted or killed in their early and most susceptible stage of growth. They also found that the division of a grass area into several compartments and the rotation of the grazing in such compartments, enabled fresh growth of grass to take place, and this ultimately increased the yield of the area.

Scott (1952), in referring to Natal sweetveld in which many annual grasses abound, regards it as essential to allow these grasses to seed as often as possible in order to allow for regeneration of

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the species. In addition, he emphasized the need for a system of management which aimed at a rest in spring to allow for reserves to give forth new growth, a seed rest to allow for regeneration and an autumn rest to allow for translocation and build-up of reserves.

Khan (1952) found that when heavily grazed rangelands were closed to grazing for a season or two the yield of grasses was improved both in quality and quantity. Navoh (1955) at Rehovot, Israel, successfully used close management to suppress weeds, and deferment to allow seeding and to afford protection of the first autumn growth.

Khan and Bhatti (1956) in Pakistan, found that periodic closure of veld benefited Chrysopogon monticola, Heteropogon contortus and Pennisetum orientale, while Cynodon dactylon and Dicanthium annulatum were relatively resistant and the need for closure was much less. At the Katherine Research Station in the Australian Northern Territory (Anonymous, 1959), a rotational grazing trial of two weeks grazing and eight weeks rest at three intensities over a three-year period, gave satisfactory results.

Kong and Merril (1960) found a four-pasture, three-herd system, whereby the grazing of one camp is deferred for four months, to result in better range condition and forage production as compared to continuous grazing under identical grazing intensities. Haynes (1943), working on unfertilized pastures of the humid, north-eastern United States, found small and insignificant differences between continuous light grazing and rotational grazing. Haynes and Neal (1943) found erosion losses on a twenty per cent slope under lightly and rotationally grazed plots not significantly different. In addition, the percentage of available forage utilized by grazing animals was less under rotational than under continuous grazing.

The small differential effect in the botanical composition of the various systems might be due to the overruling importance of moisture and temperature, factors which Speddell (1959) claims may mask the effect of other factors. Extreme temperatures limiting

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plant growth were seldom experienced during the nine seasons. Moisture, in fact, was deficient at some time or other, during all nine seasons, with a prolonged drought in 1949.

Unfortunately, although veld reserves were put aside at the commencement of these experiments, no plant counts were undertaken in these exclosures concurrently with those of the grazing systems. Consequently, the effect of weather fluctuations, and in particular drought and its effect on the veld, remain unknown entities. It is possible that the 1949 drought and the good rainfall years immediately following it might have had an equalizing effect on the floristic composition of the different systems. In this connection Coupland (1958) found, on badly depleted grassland in the Canadian Great Plains, that the decades following drought were characterized by secondary plant succession back towards the climax without any differential effect between grazing experiments. Nerney (1958) in Arizona found that the density of weeds increased during years with normal and above normal rainfall.

The reversion of the veld to a biotic sub-climax is fortunately characterized by greatly increased numbers of Eragrostis lehmanniana and other seral and pioneer grasses. Stock took these readily in early-summer, thereby relieving some of the grazing pressure from the perennial tuft grasses. These benefited greatly at a stage when they were most susceptible to defoliation.

The prevention of grasses from running into seed under continuous use suggests a more intense use of preferred species. This is confirmed by experiments conducted at the Manitou Experimental Forest (Anonymous, 1957a). These workers found an inverse relationship to exist between intensity of use and percentage of plants flowering. The unevenness of the sward under continuous grazing need not raise undue alarm since West (1952) points out that, "in dry country attempts to overcome the effects of selective grazing by increasing the grazing pressure in order to obtain even grazing seem invariably to have a bad effect both on the veld and on the

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grazing animal."

A serious defect common to both rotational systems was the closure of some camps in late-winter and spring. Under conditions in the five-camp system three-fifths of the area, and in the case of the three-camp system, two-thirds of the area was closed to grazing in this way. Late-winter and spring proved the most critical season for steers. With all the area available with shrubs in abundance and also some grasses, less severe losses in liveweight might have resulted than was actually the case.

In general, livestock reaction to different grazing systems was similar. This is in conformity with results of Black and Savage (1948) who found rotational grazing to improve the vegetation but not to have any advantage over continuous grazing in respect of liveweight. Heady (1961) in a review of continuous and specialized grazing systems, comes to the following conclusion, "a specialized grazing system has no advantages in livestock production over continuous grazing, at least with good or excellent ranges under comparable stocking intensities and degree of care in other management practices."

Gains in these experiments at Koopmansfontein were found to range between 70 and 439 pounds per steer for the summer months, the mean for all seasons and systems being between 296 and 329 pounds. This is at the higher limit of what Norman (1961)found at Katherine in Australia. He found steers to gain between 100 and 300 pounds from the beginning of the wet season until one or two months after the rains end.

The lower loss in liveweight experienced by steers under grazing systems might have been the result of steers being changed over to rested veld in spring. This enabled them to graze their fill over a smaller area, thereby reducing their maintenance requirements and having more nutrients from the ingested material available to stave off loss in condition. But whether the cost of erecting two or more dividing fences is justified to effect an end of season gain greater

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by thirty-odd-pounds per steer in the case of dolomite and not to benefit steers at all in the case of limeveld, is doubtful.

The lower gain in summer on limeveld under the five-camp system could not be held against the grazing system as such, since the same system on dolomiteveld resulted in the best production. It could rather be ascribed to the high incidence of Cymbopogon in this experiment. This species was not relished at all in summer and steers were therefore obliged to fall back on fewer palatable grasses on which to gain in condition.

In the liveweight tables a distinction is made between gains, losses and maintenance. However, these criteria are all interdependent and culminate in total digestible nutrients. With higher summer gains more liveweight must be maintained, and with higher spring losses, less liveweight need be maintained. On an average for all systems, for every 100 pounds T.D.N. obtained, 77 pounds were diverted to maintaining steers and 23 pounds were used for gaining weight. Nine pounds out of every 100 pounds T.D.N. obtained were lost in spring. This loss is low when T.D.N. obtained only is considered, but appreciable when weighed against liveweight gains.

The time to remove steers from experimental veld, in cases of herbage shortage, was decided upon rather subjectively. For this reason the actual length of time animals were off the experiments could not be held strongly against any system in particular. A fact of importance is that steers had to be removed at all. This would suggest that to expect a system in itself to overcome the worst droughts without paying regard to other measures would be an unrealistic approach. Moving stock to better pastures or supplementation during periods of herbage minima appears to be the only solution in surmounting incidental drought.

The five-camp system on lime and continuous grazing on dolomite yielded the poorest carcases. This is in agreement with lower liveweight maintenance and T.D.N. obtained by steers under these conditions.../102

ditions. The reason for the poor production from these two systems could be that their veld had among the lowest climax grass numbers of all should Cymbopogon be disregarded in the counts. The fact is that steers discriminated against this species. It is in profit per morgen per year and in rate of interest that continuously grazed dolomite and the five-camp system on lime proved inferior to the other systems. It is also on these scores that continuously grazed limeveld yielded less than the three-camp system on lime.

Experiments 6 L and 6 D were conducted at a grazing intensity of a steer to eight morgen. In addition, they had only five seasons in common with the twelve and six morgen per steer experiments already discussed. Bearing this in mind, a considerable increase in the profit per morgen and rate of interest, from the six to the eight morgen stocking intensities, took place. A much lower increase occured from the eight to the twelve morgen per steer grazing rates. This suggests that eight morgen per steer might be approaching optimum average grazing intensity in terms of profit and interest on investment.

In terms of T.D.N. acquired and liveweight maintained per morgen, both eight and six morgen stocking intensities resulted in similar amounts. This implies that increased nutrients are not procurable at heavier than eight morgen per steer grazing rates; in going up the scale to the twelve morgen intensities, on the one hand, liveweight maintenance and total digestible nutrients show a decrease, but on the other hand, these yielded the highest profit per morgen and the highest rate of interest.

In spite of extremely heavy Geigeria africana populations, no "vermoersiekte" occurred. As an explanation it is suggested that pasturage preferable to steers were always available and that they were never obliged to subsist, in part or entirely, on this bush. It was occasionally grazed, but never in amounts deleterious to the health of the animals.

The most important conclusion arrived at and practical value of

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these experiments is that neither from the vegetational, nor from the stock production aspect, is there much to choose between the various systems used. Farmers who had been following a continuous grazing system were quite justified in doing so. It is the cheapest and saves two fences on the three-camp and four on the five-camp system. However, it must be emphasized that these remarks apply strictly to circumstances where camp size varied from eight to twenty-four morgen with watering points a maximum distance of 1500 yards from the furthest point in any particular camp.

In this connection, it is illuminating to have Heady (1961) attempting to answer the question of,"why does deferred-rotation grazing show significant results in the management of land while it has not been proved superior under experimental test." He suggests that the answer might lie in other features of management when a rancher begins deferred-rotation systems. Among others, a change in stocking rate, redistribution of animals and brush control is mentioned. For conditions ruling in Griqualand West, the following improved stock management measures may be added: regular and sufficient phosphorus-licks; more watering points; closer culling of non-productive animals; regular immunization against endemic diseases; regular drenching against internal parasites; breeding and lactating seasons coinciding with the period of maximal production of the veld; the use of a sufficient number of sires and generally improved supervision.

In practice, a two-camp system, similar to that described by Nestert (1952), whereby one camp is grazed continuously while the other is being kept as a winter and spring reserve, seems to suggest itself. Camps should be grazed and rested in alternate growing seasons. Resting of camps should commence a few days after the first good spring or early-summer rains. Camps should continue to be rested until after the first killing frosts the following winter. Only then should both camps be made available to stock right up to the time of the occurrence of the first good rains after winter.

ANNEXURE 4.../104

ANNEXURE 4.

LIVEWEIGHT GAINS AND LOSSES AND LIVEWEIGHT MAINTAINED ON LIMEVELD IN LBS. T.D.N.

AND CONTRIBUTION OF THESE FACTORS TO T.D.N. PROCURED PER MORGEN.

Seasons.	Rainfall(m.m.)	Expt. 6 L. Three-camp system. Liveweight maintained	Gains	T.D.N.	Losses	Net T.D.N.	Expt. 7 L - Continuous grazing. Liveweight maintained	Gains	T.D.N.	Losses	Net T.D.N.	Expt. 8 L - Five-camp system. Liveweight maintained	Gains	T.D.N.	Losses	Net T.D.N.
1944/45(y)	255	543	157	700	64	636	674	159	833	82	731	525	109	634	65	569
1945/46(y)	268	707	182	889	110	779	742	201	943	96	847	654	161	815	100	715
1946/47(x)	300	215	42	257	18	239	206	46	252	37	215	206	44	250	27	223
1947/48	466	414	169	583	34	549	415	198	613	45	568	384	150	534	33	501
1948/49	151	439	93	532	47	485	427	122	549	73	476	396	101	497	54	443
1949/50(y)	588	607	246	853	67	786	628	251	879	47	832	569	210	779	48	731
1950/51	470	358	92	450	18	432	361	96	460	21	436	350	93	443	34	409
1951/52	288	409	92	501	55	446	387	95	482	65	47	405	108	513	63	450
1952/53	418	396	147	543	43	500	370	136	506	43	463	390	137	527	47	480
Mean per season.	356	454	136	590	51	539	468	145	613	57	556	431	124	555	52	503
Per cent.	-	77	23	100	9	91	76	24	100	9	91	78	22	100	9	91

(y) = Exceptionally long seasons.

(x) = Exceptionally short seasons.

ANNEXURE 5.

LIVEWEIGHT GAINS AND LOSSES AND LIVEWEIGHT MAINTAINED ON DOLOMITEVELD IN LBS. T.D.N.

AND CONTRIBUTION OF THESE FACTORS TO T.D.N. PROCURED PER MORGEN.

Seasons.	Rainfall (m.m.)	Expt. 6 D – Three-camp system. Liveweight maintained	Gains	T.D.N.	Losses	Net T.D.N.	Expt. 7 D – Continuous grazing. Liveweight maintained	Gains	T.D.N.	Losses	Net T.D.N.	Expt. 8 D – Five-camp system. Liveweight maintained	Gains	T.D.N.	Losses	Net T.D.N.
1944/45(y)	255	549	184	733	97	636	616	157	773	103	670	577	126	703	59	644
1945/46(y)	268	684	135	819	60	759	740	198	938	96	842	782	200	982	103	879
1946/47(x)	300	202	31	233	23	210	194	21	215	29	186	209	47	256	27	229
1947/48	466	392	168	560	22	538	402	190	592	34	558	416	180	596	30	566
1948/49	151	455	119	574	68	506	350	47	397	60	337	431	108	539	55	484
1949/50(y)	588	689	193	882	53	829	570	220	790	42	748	614	223	837	46	791
1950/51	470	354	98	452	26	426	355	102	457	26	431	370	93	463	19	444
1951/52	288	395	109	504	64	440	383	125	508	73	435	398	99	491	66	431
1952/53	418	433	162	595	34	561	405	137	542	52	490	406	141	547	32	515
Mean per season.	356	461	133	594	50	544	446	133	579	57	522	467	135	602	48	554
Per cent.	–	78	22	100	8	92	77	23	100	10	90	78	22	100	8	92

(y) = Exceptionally long seasons.

(x) = Exceptionally short seasons.

CHAPTER IV.

THE EFFECT OF STOCKING RATE AND ROTATIONAL GRAZING ON SHEEP PRODUCTION.

The practice among sheep farmers on the Ghaap plateau is to breed sheep without restriction of their numbers. In the old days they were grazed under the care of a herdsman during the daytime and kraaled at night. After the introduction of vermin-proof fencing sheep were free ranged. They were grazed all over the farm without regard to veld management or improvement for maximal production. "Vermoersiekte" occurred generally and deaths due to starvation were common.

Because of the advanced degree of veld impoverishment and recurring outbreaks of "vermoersiekte" of increasing severity, two series of experiments, employing wethers as grazers of veld, were initiated to compare:

A. Two rates of stocking under continuous grazing, and

B. Five grazing systems at a stocking rate of one sheep per morgen.

The purpose of these experiments was to determine how the veld could be managed and at what grazing intensity it be grazed so that sheep would derive maximum benefit commensurate with veld conservation and improvement.

In this respect Davies (1940) gave early direction regarding the nature of investigations to be undertaken: "In the semi-arid pastoral areas on which the carrying capacity is below a sheep to 1.5 acres, the prevention of deterioration of the plant cover by exploitative grazing is the most important phase of pasture research."

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A. GRAZING INTENSITIES.

The experiments were carried out on lime and dolomiteveld respectively under both rates of grazing. Data from experiment 4 D formed part of the material of a thesis submitted by the author to the University of the Witwatersrand for the degree of Master of Science in the Botany Department. Table XXVIII gives details of the four grazing intensity experiments.

TABLE XXVIII.

GRAZING INTENSITY WITH SHEEP ON VELD.

Experiment No.		Particulars.
12 L.	Limeveld	: 18 sheep continuous on 12 morgen.
4 L.		: 12 sheep continuous on 12 morgen.
12 D.	Dolomiteveld	: 18 sheep continuous on 12 morgen.
4 D.		: 12 sheep continuous on 12 morgen.

Experiments 4 L, 12 L and 12 D were commenced in February 1950 and experiment 4 D four years earlier. They were discontinued in July 1957 except for experiment 4 D which was terminated in July 1953.

Veld and sheep interaction was measured by means of:

(1) Frequency estimates of plants,

(2) Field observations,

(3) Soil analysis,

(4) Liveweight changes,

(5) Liveweight-curve area, and

(6) Geigeria-poisoning and other losses.

(1) PLANT FREQUENCY ESTIMATES:

In Tables XXIX and XXX the change in the frequency of plants during the experimental period is given for lime and dolomiteveld respectively.

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TABLE XXIX.

PLANT RESPONSE TO TWO GRAZING INTENSITIES WITH SHEEP ON LITEVELD AT KOOPMANSFONTEIN.

	Frequency per 60 quadrats (a)			
	Expt.4 L(1m/sh)		Expt.12 L(2/3m/sh)	
	1951	1957	1951	1957
CLIMAX SPECIES:				
Themeda triandra.....	6	0**	0	0
Chrysopogon montanus	2	1	2	0
Digitaria eriantha.....	6	5	3	0
Fingerhuthia africana.....	2	0	2	0
Sporobolus fimbriatus	9	9	0	0
Cymbopogon plurinodis.....	0	0	2	0
SERAL SPECIES:				
Eragrostis lehmanniana.....	3	8	9	7
E. obtusa.....	0	1	0	0
Cropetium capense.....	20	29	16	23
PIONEER SPECIES:				
Enneapogon brachystachyus....	21	38**	26	29
Aristida curvata.....	24	31*	39	28*
Tragus racemosus.....	27	16*	8	1*
WEEDS:				
Geigeria africana.....	18	48**	9	32**
Chrysocoma tenuifolia..	2	4	4	18**
Tribulus terrestris.....	0	2	0	0
KARROID SPECIES:				
Aster muricatus.....	3	1	0	1
OTHER SPECIES:				
Woody.....	0	3	3	5
Herbaceous.....	34	36	18	9*

Woody species comprise the genera Euclea, Tarchonanthus, Rhus, Asparagus and Acacia.

Herbaceous species comprise the genera Bulbostylis, Oxalis, Sericorema, Barleria, Stachys, Commelina, Cyperus, Euphorbia, Walafrida, Moraea, Blepharis, Pharnaceum and Amaranthus.

* = Significant difference at P = 0.05

** = Significant difference at P = 0.01

(a) = Surveys according to the method by Van Broembsen (1951).

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TABLE XXX.

PLANT RESPONSE TO TWO GRAZING INTENSITIES WITH SHEEP ON DOLOMITEVELD AT KOOPMANSFONTEIN.

	Number of plants per 15 quadrats(s)		Frequency(n) per 60 quadrats(r).	
	Expt.4 D(1m/sh)		Expt.12 D(2/3m/sh)	
	1947	1953	1951	1957
CLIMAX SPECIES:				
Themeda triandra.....	2	4	6	0
Chrysopogon montanus.....	14	40	0	0
Diheteropogon eriantha.....	17	35	0	0
Fingerhuthia africana.....	22	0	0	0
Sporobolus fimbriatus.....	0	4	0	0
Cymbopogon plurinodis.....	1	0	0	0
Heteropogon contortus.....	50	7	2	0
Enneapogon scoparius.....	42	47	1	1
Eustachys paspaloides.....	5	1	0	0
Aristida vestita.....	5	4	0	0
Sub-total	158	142		
SERAL SPECIES:				
Eragrostis lehmanniana.....	68	463	24	18
E. obtusa.....	0	0	0	1
E. denudata.....	43	95	0	7
Cropetium capense.....	0	0	23	53
Brachiaria eruciformis.....	0	0	0	1
Tragus koeleriodes.....	1	0	0	0
Sub-total	112	558		
PIONEER SPECIES:				
Enneapogon brachystachyus....	15	333	20	39
Aristida curvata.....	12	15	47	28
Tragus racemosus.....	24	224	28	16
Sub-total	51	572		
WEEDS:				
Geigeria africana.....	6	84	2	0
Chrysocoma tenuifolia.....	5	2	0	0
Tribulus terrestris.....	4	17	0	0
Sub-total	15	103		
KARROID SPECIES:				
Indigofera patens.....	0	0	0	1
OTHER SPECIES:				
Woody.....	10	16	0	0
Herbaceous.....	12	37	12	74
Sub-total	22	53		
GRAND TOTAL	358	1428		

Woody species comprise the genera Euclea, Tarchonanthus, Rhus and Asparagus.

Herbaceous species comprise the genera Oxalis, Sericorema, Barleria, Stachys, Commelina, Cyperus, Walafrida, Moraea, Blepharis and Pharnaceum.

* = Significant difference at P = 0.05.
** = Significant difference at P = 0.01.
(n) = Frequency of different species is not additive
(r) = Surveys according to a method described by Van Breemsen(1951)
(s) = Surveys according to the method of Raunkiaer as described by Murray (1946).

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Because of the inadequacy of the method of plant counts, large changes only in the frequency will be considered.

Climax grasses were unable to tolerate severe grazing by sheep but they withstood moderate grazing at the rate of a sheep per morgen. Fingerhuthia africana on both veld types and Themeda triandra on lime did not stand up to either moderate or severe grazing. Seral, pioneer, karroid and other species remained stable under both intensities on limeveld and under the severe intensity on dolomite but increased under the moderate grazing rate on dolomiteveld.

In particular the increase in Eragrostis lehmanniana, Enneapogon brachystachyus and Tragus racemosus on dolerite are noteworthy. In addition, under both moderate and severe grazing Heteropogon contortus declined and Eustachys paspaloides was practically eliminated.

Severe grazing on limeveld resulted in a significant increase of Chrysocoma tenuifolia. Under the moderate intensities it was kept in check.

Owing to pronounced seasonal variation in the occurrence of Geigeria africana no deductions from the counts of two isolated seasons are justified.

(2) FIELD OBSERVATIONS:

Sheep preferred Themeda triandra and Eragrostis lehmanniana to all other grasses. During the greater part of the year they discriminated against Cymbopogon plurinodis, discrimination being most pronounced under the moderate and less so under the severe grazing intensities. In spring, however, when fresh sprouts of other grasses were grazed off, sheep grazed the green sprouts of this species from in among old grass in the tufts until the onset of rains. Deeper soil sites were occupied by Aristida curvata.

Perennial grasses were confined to rocky outcrops except under moderately grazed dolomite where grasses formed a continuous stand.

Under the severe intensities, particularly in seasons with abundant rain, a few perennial grasses managed to seed. All grasses,

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with the exception of Cymbopogon plurinodis, were gradually grazed down to the ground and no area selection was evident.

Sheep started browsing shrubs earlier in winter under the severe intensities than under the moderate intensities. Tarchonanthus minor was always preferred to other shrubs, and was browsed until only thick branches remained. Sheep took other shrubs reluctantly, returning to T. minor whenever new growth became available. At the end of the dry season all shrubs were devoid of leaves as far as sheep could reach.

Towards the termination of the experiments Eragrostis lehmanniana and Tarchonanthus camphoratus var. litakunensis constituted the the bulk of available herbage. An exception here was found in moderate grazing on dolomite where tuft grasses abounded. In both limeveld experiments and also in the severe grazing experiment on dolomite the grazing pressure was excessive and caused plants to be unthrifty and the surface soil to be blown in under the shrubs and fences.

(3) SOIL ANALYSIS:

In Tables XXXI and XXXII particulars are given of mechanical and chemical analyses of soils, derived from experiments on lime and dolomiteveld respectively, after being exposed to the different grazing intensities for the duration of these experiments.

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TABLE XXXI.

MECHANICAL AND CHEMICAL ANALYSES(s) OF LILEVELD SOILS UNDER TWO GRAZING RATES WITH SHEEP AT KOOPMANSFONTEIN.

	Expt. 12 L (2/3m./sheep)			Expt. 4 L (1m./sheep)		
Soil horizon (inches).	0-3	3-6	6-12	0-3	3-6	6-12
pH.	7.30	6.90	7.04	7.35	6.85	6.83
Resistance at 60°F.	1330	1450	1420	1150	1520	1490
Mechanical analysis (%):						
Sand (>0.02 mm.)	84.51	83.86	82.69	80.39	83.41	82.65
Silt (0.02 - 0.002 mm.)	5.87	5.51	4.82	8.83	5.35	4.51
Clay (<0.002 mm.)	9.62	10.63	12.49	10.78	11.24	12.84
$CaCO_3$ (%).	0.00	0.00	0.00	0.09	0.00	0.00
P (%) (z).	.0022	.0007	.0004	.0025	.0006	.0003
C (%).	0.71	0.68	0.41	0.93	0.60	0.47
N (%).	0.09	0.07	0.05	0.11	0.07	0.05
C : N ratio.	8.4:1	9.4:1	8.2:1	8.8:1	8.8:1	10.2:1
Water-soluble salts (%)(n):						
Na.	.0011	.0012	.0013	.0011	.0019	.0009
K.	.0015	.0007	.0014	.0007	.0003	.0002
Ca.	.0048	.0044	.0042	.0037	.0041	.0028
Mg.	.0004	.0006	.0005	.0012	.0006	.0017
HCO_3	.0152	.0144	.0158	.0115	.0109	.0105
Cl.	.0024	.0027	.0032	.0024	.0030	.0024

(s) = Analyses by D.F.M. Claassen.

(z) = 1% Citric acid solution.

(n) = Soil : Water :: 1 : 2.

There is no difference between the soils of the two grazing rates as far as their depth tendencies are concerned. In the upper horizon the phosphorus, carbon and nitrogen status, the silt and clay fractions, in addition to the magnesium content of soils under moderate grazing are higher than these of soils under severe

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grazing. On the other hand, the sand fraction and Potassium, Calcium and Bicarbonate contents of surface soils under severe grazing are higher than that of soils under moderate grazing.

TABLE XXXII.../114

TABLE XXXII.

MECHANICAL AND CHEMICAL ANALYSES(s) OF DOLOMITEVELD SOILS UNDER TWO GRAZING RATES WITH SHEEP AT KOOPMANSFONTEIN.

	Expt. 12 D (2/3m./sheep)			Expt. 4 D (1m./sheep)		
Soil horizon (inches)	0-3	3-6	6-12	0-3	3-6	6-12
pH.	6.98	6.87	6.88	7.40	7.48	7.55
Resistance at 60°F.	1050	1320	1300	1200	1050	1150
Mechanical analysis (%):						
Sand (>0.02 mm.)	81.20	79.51	80.06	81.02	82.11	81.20
Silt (0.02 - 0.002 mm.)	5.96	5.89	5.43	9.65	8.12	6.41
Clay (<0.002 mm.)	12.84	14.60	14.51	9.18	9.77	12.39
$CaCO_3$ (%).	0.03	0.00	0.00	1.71	0.72	0.22
P (%) (z).	.0037	.0027	.0010	.0036	.0033	.0019
C (%).	1.01	0.86	0.54	1.67	1.16	0.60
N (%).	0.12	0.11	0.07	0.15	0.13	0.07
C : N ratio.	8.6:1	7.9:1	7.7:1	11.0:1	8.8:1	8.2:1
Water-soluble salts (%) (n):						
Na.	.0013	.0012	.0010	.0009	.0010	.0010
K.	.0011	.0004	.0002	.0012	.0010	.0003
Ca.	.0057	.0021	.0026	.0057	.0054	.0015
Mg.	.0002	.0009	.0015	.0033	.0033	.0024
HCO_3.	.0152	.0085	.0038	.0256	.0148	.0141
Cl.	.0027	.0027	.0021	.0038	.0044	.0038

(s) = Analyses by D.F.M. Claassen.

(z) = 1% Citric acid solution.

(n) = Soil : Water :: 1 : 2.

With increasing depth of soil, there is no difference in the tendencies between the grazing rates. In the 0-3 inch horizon, the silt and clay fractions of the two grazing rates are in inverse relation to each other, high clay under severe grazing being associated with low silt content. Soils under moderate grazing had a higher carbon and nitrogen status and a wider carbon to nitrogen ratio for

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all horizons than soils under severe grazing.

(4) LIVEWEIGHTS:

In Tables XXIII and XXIV the average liveweight gains and losses , liveweight maintained and total digestible nutrients obtained are given for sheep grazing lime and dolomiteveld under two rates of grazing.

TABLE XXXIII

GAINS AND LOSSES PER SHEEP[(m)] : LIVEWEIGHT MAINTAINED AND T.D.N. OBTAINED IN POUNDS PER MORGEN ON LIMEVELD UNDER TWO GRAZING RATES.

Seasons.	Total Rainfall (mm.)	Expt. 12 L - (0.67 morgen/sheep). Summer Gains	Spring Losses	Net Gains	Liveweight maintained per morgen	Net T.D.N. per morgen.	Expt. 4 L - (1 morgen/sheep). Summer Gains	Spring Losses	Net Gains	Liveweight maintained per morgen	Net T.D.N. per Morgen.
1949/50.	588	36	3	33 (s)	33121	459	37	5	32	22081	370
1950/51.	470	12	5	7	30166	389	21	2	19	21658	317
1951/52.	288	15	20	-5 (t_1) (rp_2)	36720	429	18	17	1 (np_3)	29988	348
1952/53.	418	15	13	2 (x_8p_3)	38090	463	24	9	15	26530	366
1953/54.	378	11	17	-6 (p_6)	43016	482	19	14	5 (p_5)	47916	396
1954/55.	459	25	24	1 (sv_8p_8)	43253	531	19	19	0 (pv_2)	47085	375
1955/56.	563	21	27	-6 (p_1)	33306	383	15	8	7 (p_2)	35490	260
1956/57.	427	24	18	6	19824	300	21	15	6	20160	187
Mean per season.	449	20	16	4	-	-	22	11	11	-	-
Mean per morgen per season.		30	24	6	34687	430	22	11	11	31364	327

s_1, t_1, P_2, v_8, etc. = Sub-notation denotes the number of animals involved.

s = Sheep died from Hydrocyanic poisoning.

t = Sheep sick from Geigeria poisoning.

r = Sheep removed from 5/11/52 - 10/2/53 due to herbage shortage.

n = Sheep removed from 11/11/52 - 10/2/53 due to herbage shortage.

p = Sheep died from poverty.

x = Sheep removed 29/12/53 - 23/2/54 due to herbage shortage.

v = Sheep died from Geigeria poisoning.

o = Ewes replaced wethers on the experiments from this season onwards.

m = Weights are the mean of 18 and 12 sheep for experiments 12 L and 4 L.

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TABLE XXXIV.

GAINS AND LOSSES PER SHEEP(m) : LIVEWEIGHT MAINTAINED AND T.D.N. OBTAINED IN POUNDS PER MORGEN ON DOLOMITEVELD UNDER TWO GRAZING RATES.

Seasons.	Total Rainfall (mm.)	Expt. 12 D - (0.67 morgen/sheep) Summer Gains.	Spring Losses	Net Gains	Liveweight maintained per morgen	Net T.D.N. per morgen.	Expt. 4 D - (1 morgen/sheep). Summer Gains.	Spring Losses	Net Gains	Liveweight maintained per morgen	Net T.D.N. per morgen.
1945/46.	268	-	-	-	-	-	17	13	4	35616	433
1946/47.	300	-	-	-	-	-	24	15	9	39092	389
1947/48.	466	-	-	-	-	-	28	3	25(*)	32942	469
1948/49.	151	-	-	-	-	-	33	18	15(r)	28465	394
1949/50.	588	15	0	15	13728	237	38	11	27(s)	36822	527
1950/51.	470	26	0	26	28178	461	16	5	11	26741	350
1951/52.	288	22	13	9	42228	548	31	4	27(s)	16524	288
1952/53.	418	51	7	44	42638	729	36	4	32(p)	34848	516
1953/54.	378	34	15	19	58806	789	-	-	-	-	-
1954/55.	459	24	12	12	35582	444	-	-	-	-	-
1955/56(o).	563	27	16	11	41904	559	-	-	-	-	-
1956/57.	427	20	21	-1 (p)	23182	290	-	-	-	-	-
Mean per seasons '49/'57 '45/'53.		27	10	17	-	-	8	9	19	-	-
Mean per morgen per season '49/'57, '45/'53.		41	16	25	35782	507	28	9	19	31381	421
Mean per season 1949/1953		29	5	24	-	-	30	6	24	-	-
Mean per morgen per season 1949/1953.		44	8	36	31693	494	30	6	24	28734	420

m = Weights are the mean of 18 sheep for experiment 12 D and 12 sheep for experiment 4 D.

r = Sheep removed 8/11/49 - 10/1/50, due to herbage shortage.

s_1 = Sheep died from Hydrocyanic poisoning.

p_1 = Sheep died from poverty.

t = Sheep sick from Geigeria poisoning.

o = Ewes replaced wethers on the experiments from this seasons onwards.

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On a per sheep basis, summer gains from the two grazing intensities on limeveld were similar. The same applies to different grazing rates on dolomite, but here higher summer gains than on lime were recorded. On dolomite, spring losses and net gains from the two grazing rates did not differ much. On lime, however, severe grazing resulted in an 80 per cent spring loss as against a 50 per cent spring loss for moderate grazing.

On a per morgen basis, sheep on severely grazed lime registered a higher summer gain than sheep on the moderate stocking rate. But as a result of the lower liveweight loss in spring moderate grazing ended the season with more net gains to its credit. Per morgen summer gains on severely grazed dolomite were higher than on moderate grazing. In spite of more weight lost in spring from severe grazing, sheep still ended the season with more net gains than sheep under moderate grazing.

Both veld types yielded more total digestible nutrients and resulted in higher liveweight maintenance under severe grazing. On lime, both stocking rates failed to carry their sheep through the 1952/53 season and severe grazing failed once more in the next season. On dolomite, moderate grazing failed once in the 1949/50 season.

(5) AREA OF THE LIVEWEIGHT-CURVE.

In Tables XXXV and XXXVI this measurement of sheep reaction to grazing is given for lime and dolomiteveld respectively.

TABEL XXXV.../119

TABLE XXXV.

AREA(n) BELOW THE LIVEWEIGHT-CURVE OF SHEEP GRAZING LIMEVELD UNDER TWO GRAZING RATES.

Period on Experiment	Expt.4 L 1 m. Area.	Expt.12 L 0.67 m. Area.	Calculated values of t	P	Significant Differences (P<0.010)
28.2.50 - 17.6.52.	2625	2386	2.58	0.005	4 L> 12 L
18.6.52 - 12.7.55.	3085	2752	2.91	0.002	4 L>12 L
13.7.55 - 19.2.57	1142	1067	1.66	0.049	N.S.

(n) = The area of the liveweight-curve was calculated from the average liveweight of 18 sheep and 12 sheep for Experiments 12 L and 4 L respectively.

Moderate grazing, with two out of three lots of experimental sheep, resulted in significantly greater areas of the liveweight-curve in comparison with severe grazing.

TABLE XXXVI.

AREA BELOW THE LIVEWEIGHT-CURVE OF SHEEP GRAZING DOLOMITEVELD UNDER TWO GRAZING RATES.

Period on Experiment	Expt.4 D 1 m. Area(n)	Expt.12 D 0.67 m. Area(n)	Calculated values of t	P	Significant Differences (P<0.010)
5.2.46 - 25.5.48	3407	-	-	-	-
26.5.48 - 14.8.51	3794	-	-	-	-
15.8.51 - 15.7.53	1827	-	-	-	-
15.8.50 - 17.6.52	-	2116	-	-	-
18.6.52 - 12.7.55	-	3313	-	-	-
13.7.55 - 19.2.57	-	1231	-	-	-

(n) = The area of the liveweight-curve was calculated from the average liveweight of 18 sheep and 12 sheep for Experiments 12 D and 4 D respectively.

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The two dolomite grazing rate experiments were not executed simultaneously and as a consequence sheep were not matched. This precludes comparison of the areas of the liveweight-curves to be made. Bearing in mind the late commencement of the severe grazing rate, the areas of the liveweight-curve of sheep under moderate grazing were consistently higher than those of sheep under severe grazing.

(6) GEIGERIA-POISONING AND OTHER LOSSES.

Moderate grazing on dolomite resulted in two sheep dying from hydrocyanic poisoning and one sheep as a result of poverty. Under the severe intensity two sheep were lost from poverty and one sheep from hydrocyanic poisoning. No Geigeria-poisoning occurred.

On severely grazed limeveld, losses amounted to 20 sheep dying from poverty, eight from Geigeria-poisoning and four as a result of hydrocyanic poisoning; under the moderate intensity, eleven sheep died from poverty and two as a result of Geigeria-poisoning. All deaths due to Geigeria-poisoning occurred since July 1955 from which date ewes were being grazed on the experiments.

DISCUSSION:

At the commencement of the experiments the veld was composed of a number of climax grasses, other grasses and herbs. During the course of these grazing rate experiments the veld reverted to a biotic sub-climax under sheep grazing. This sub-climax stage is fairly high in the succession under moderate grazing and is made up of a fair number of climax grasses and other seral species. In contrast with this, the sub-climax stage under severe grazing is low in the succession and consists mainly of seral, pioneer, weed, karroid and other species with few or no climax grasses.

The decline and eventual disappearance of climax grasses from severely grazed veld may be attributed to continual removal by sheep of all leaves and stems of grasses. The plants were therefore

unable.../121

unable to set seed or to replenish root reserves adequately. This in turn prevented seedlings from re-occupying the ground and existing tufts from regaining full vigour. The results obtained in these experiments is contrary to the experience of Biddiscombe, Hutchings, Edgar and Cuthbertson (1956) in New South Wales. There they found the number of plants of the perennial grass component tended to be higher with heavy stocking in veld composed mainly of Stipa, Chloris and Digitaria. It is however possible that the heavy stocking used by these workers might not have been as severe as that of the grazing rate experiments under discussion. This could account for the differing results obtained. Boyko (1952) describes the arid zones as being situated on the border regions of survival possibilities for the various species and of vegetation as a whole; he cautions against even the smallest change in the factors involved in that they may play an altogether decisive role in plant survival.

Under moderate, continuous grazing, however, different conditions existed. Sufficient stems and leaves or portions of leaves were left ungrazed by sheep. This enabled plants to seed, thereby propagating themselves. In addition, root reserves accumulated and vigour was restored to the climax grasses.

Fingerhuthia africana again proved intolerant even to moderate use. The results obtained with this species under cattle grazing experiments is confirmed by this fact. This species seems to hold out promise as an important criterion of veld use, both where cattle and where sheep are being grazed.

The increase of Enneapogon brachystachyus and Tragus racemosus on lightly stocked dolomite runs contrary to the experience of Biddiscombe et al (1956). These workers found light stocking provided a significantly lower percentage of annuals in the total green feed of stock. The decrease of Aristida curvata on severely grazed lime and dolomiteveld differs from the species response obtained by Thomas and Young (1954) in Texas. These investigators found three-awn species (Aristida spp.) to increase under heavy sheep grazing but

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to decrease under cattle grazing. The divergence in the response of annual grasses may possibly be ascribed to the nature of the year in which the final counts were undertaken. It was most likely a favourable season for germination and growth of E. brachystachyus and Tragus racemosus but not for A. curvata. It is unlikely that the seed supply of A. curvata became exhausted through years of close grazing. Seeds of this grass are carried far and wide by the wind and the animals, and the camps were surrounded by large tracts of veld in which A. curvata grew in profusion.

The movement of soil from the ground between bushes towards the shrubs is explained by Kucera (1958) who found transient types of vegetation not as effective in retarding surface loss of soil. He explains that such types have characteristically earlier development and lack the deep root system which are typical of perennial tuft species.

The elimination of Heteropogon contortus and Cymbopogon plurinodis, although these grasses are low in grazing preference for most of the year, could partly be due to sheep continually grazing out the green sprouts from in among the old stems and leaves in the tufts during spring. This no doubt caused great injury to these grasses at a most vulnerable stage and led to their decline and eventual disappearance.

The increase in Chrysocoma tenuifolia under severely grazed lime is attributable to reduced competition afforded by fewer climax grasses. Shaw (1875) claimed that the bitter and nauseous character of Chrysocoma gave it immunity from grazing and among others was responsible for its unhampered propagation.

Sheep appeared to favour the same grasses which cattle favoured. In addition, sheep obtained a greater proportion of their herbage from browse plants. This inference is in agreement with that arrived at by Sampson (1944) for burned chaparral in California. He found sheep to utilize all types of brushland more completely than cattle and to exhibit fewer seasonal preferences in their choice of forage.

Unfortunately.../123

Unfortunately, shrub surveys were not undertaken in these experiments and quantitative data on shrub reaction to browsing is therefore unavailable. It is, however, questionable whether the shrubs, and in particular Tarchonanthus minor, would survive continual defoliation and de-branching of such severe degree as evidenced in these experiments.

Coetsee (1961) is of the opinion that Tarchonanthus minor had been browsed to extinction by sheep over large tracts of the area. As a consequence, after frosts occur and grasses are no longer relished, sheep are obliged to fall back on Geigeria africana. In this sense, the destruction of T. minor may well be considered as a contributory cause of Geigeria-poisoning. Acocks (1953) also subscribes to the view that T. minor is being steadily grazed out.

The similar gains resulting from the different rates of grazing in summer could be because sheep obtain sufficient herbage for maximum gains on one as well as on two-thirds of a morgen of either lime or dolomiteveld. On severely grazed dolomite, enough herbage was left over from summer to tide sheep over winter and spring. Contrary to this, limeveld under severe grazing resulted in sheep losing condition to a dangerous level. This indicates a shortage of grazing during these months.

The conclusion arrived at is that severe grazing as opposed to moderate grazing led to lower summer gains on a per stock unit basis. But when this was expressed on a per unit area basis, the reverse applied. This is confirmed by Roe, Southcott and Turner (1959), investigating natural pastures in New South Wales. Those workers found the same relationship between rate of gain per and per acre, "the lightest rate of stocking slightly increa. wool production per head, but the heaviest rate greatly increasing production per acre." Heady (1961) throws some light on this anomaly when he concludes that, "Not until the animal potential to produce has been surpassed will differences in the pasture be measured in animal products"

The high spring liveweight loss of sheep under severe grazing

conforms.../124

conforms to results quoted by Eyeles (1956) in that the number of sheep turned out fat was inversely proportional to the density of stocking. Gard, Fuelleman, Van Doren and Kammalade (1943) obtained a similar result where the gross annual return from moderate grazing amounted to $6.80, while a loss of $1.10 was sustained from a comparable area of severely grazed land.

The higher maintenance and more total digestible nutrients obtained per unit area under severe grazing as opposed to those obtained from moderate grazing is in accordance with results obtained by Roe and Allen (1945). Their work indicated that one way of increasing the efficiency of use of native pastures is by increasing the rate of stocking.

Although larger amounts of T.D.N. resulted from continuous, severe stocking on limeveld, this increased efficiency of use was obtained at the cost of appreciable numbers of sheep dying from poverty. With the exception of moderate grazing on dolomite, the net gains of sheep declined between 195 nd 1957. This suggests inability of the veld to keep stock in a thrifty condition towards the closing stages of these experiments and is symptomatic of severe damage to the grazing. This applies particularly to severe grazing on dolomite.

Deaths due to poverty and Geigeria-poisoning may best be considered together because of the difficulty with which they were diagnosed. On dolomite, these losses were few and amounted to one-half per cent per annum as against two per cent for moderate and three per cent for severe grazing on lime. These losses again tend to be directly proportional to the grazing rate. An examination of these deaths in the light of severe spring loss in condition makes it abundantly clear that the amount of available herbage is closely correlated with Geigeria-poisoning and survival. With heavier grazing per unit area less herbage is available per sheep and a higher probability exists of the occurrence of Geigeria-poisoning and poverty.

The browsing of shrubs so that they become bare up to three

feet.../125

feet in height indicates the lengths to which sheep will go to survive on veld from which most grasses have disappeared. Rowlands (1959) comments on this phenomenon and refers to the fact that, "the vestiges of the sheep's foraging instinct are more marked in some sheep than in others and more marked in all sheep than in cattle, from which, by the process of domestication, it is slowly being eliminated."

Steyn (1943) was one of the first of a long line of workers who claimed that the solution of "vermoersiekte" did not lie in the discovery of a remedy but in the correct control of grazing. In these experiments, two-thirds of a morgen of veld was wholly inadequate for sheep and this intensity had disastrous effects on the veld. One morgen per sheep appeared to be the lower limit of grazing intensity for wethers. The minimum rate of grazing for ewes heavy in lamb or with lambs at foot can be expected to be nearly twice that of wethers. The increased demands of producing ewes caused the veld to fall short of their demands. To such animals, Geigeria africana provided sustenance and eating this caused ewes to fall easy prey to "vermoersiekte".

The practical implications of these experiments appear to be that a grazing rate of a dry sheep to two-thirds of a morgen on limeveld overtakes both vegetation and stock. Such concentration of stock led to the virtual elimination of perennial, leafy grasses and an alarmingly high rate of stock deaths from both poverty and "vermoersiekte". Higher up the scale a grazing intensity of one morgen limeveld per sheep appeared to be the minimum stock concentration at which fair production, commensurate with veld conservation, was feasible.

On dolomite, two-thirds of a morgen per non-producing sheep yielded satisfactory results both as regards livestock and veld. At a rate of one morgen per dry sheep the upper limit of stock concentration was reached.

ANNEXURE 6.../126

ANNEXURE 6.

LIVEWEIGHT GAINS AND LOSSES AND LIVEWEIGHT MAINTAINED IN LB. T.D.N. ON LIMEVELD AND CONTRIBUTION OF THESE FACTORS TO T.D.N. PRODUCED PER MORGEN.

		Expt. 12 L (0.67 sheep/morgen).					Expt. 4 L (1 sheep per morgen).				
Seasons.	Rainfall(mm.)	Liveweight maintained	Gains	T.D.N.	Losses	Net T.D.N.	Liveweight maintained	Gains	T.D.N.	Losses	Net T.D.N.
1949/50.	588	380	191	571	12	559	253	131	384	14	370
1950/51.	470	346	64	410	21	389	249	74	323	6	317
1951/52.	288	422	79	501	82	419	344	64	408	60	348
1952/53.	418	437	79	516	53	463	304	85	389	23	366
1953/54.	378	494	58	552	70	482	367	67	434	38	396
1954/55.	459	497	132	629	98	531	360	67	427	52	375
1955/56.	563	382	111	493	110	383	272	31	303	43	260
1956/57.	427	228	127	355	55	300	154	74	228	41	187
Mean/season.	449	398	105	503	62	441	288	74	362	35	327
Per cent.		79	21	100	12	88	80	20	100	10	90

ANNEXURE 7.../12

ANNEXURE 7.

LIVEWEIGHT GAINS AND LOSSES AND LIVEWEIGHT MAINTAINED AND CONTRIBUTION OF THESE FACTORS TO T.D.N. IN LB. T.D.N. ON DOLOMITEVELD PRODUCED PER MORGEN.

Seasons.	Rainfall (mm.)	Expt. 12 D (0.67 morgen/sheep). Liveweight maintained	Gains	T.D.N.	Losses	Net T.D.N.	Expt. 4 D (1 morgen/sheep). Liveweight maintained	Gains	T.D.N.	Losses	Net T.D.N.
1945/46.	268						409	60	469	36	433
1946/47.	300						345	85	430	41	389
1947/48.	466						378	99	477	8	469
1948/49.	151						327	116	443	49	394
1949/50.	588	158	79	237	0	237	423	134	557	30	527
1950/51.	470	323	138	461	0	461	307	56	363	13	350
1951/52.	288	485	116	601	53	548	190	109	299	11	288
1952/53.	418	489	269	758	29	729	400	127	527	11	516
1953/54.	378	675	175	850	61	789	-	-	-	-	-
1954/55.	459	409	85	494	50	444	-	-	-	-	-
1955/56.	563	481	143	624	65	559	-	-	-	-	-
1956/57.	427	266	106	[illegible]	82	290	-	-	-	-	-
Mean/season.	428	410	139	549	42	507	347	98	446	25	421
Per cent.		75	25	100	8	92	78	22	100	6	94

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B. GRAZING SYSTEMS.

Ten experiments employing five systems of veld management were carried out on both lime and dolomiteveld. Data from experiments 1 L, 2 L, 3 L, 3 D, 4 D and 5 D formed part of the material of a thesis submitted to the University of the Witwatersrand for the degree of Master of Science. Table XXXVII gives details of the different grazing system experiments.

TABLE XXXVII.

GRAZING SYSTEMS WITH SHEEP ON VELD.

Experiment No.	Particulars.
1 L.	Limeveld : 10 sheep to 10 morgen : System I.
2 L.	: 10 sheep to 10 morgen : System II.
3 L.	: 10 sheep to 10 morgen : System III.
4 L.	: 12 sheep to 12 morgen : System IV
5 L.	: 24 sheep to 24 morgen : System V.
1 D.	Dolomiteveld : 10 sheep to 10 morgen : System I.
2 D.	: 10 sheep to 10 morgen : System II.
3 D.	: 12 sheep to 12 morgen : System III.
4 D.	: 12 sheep to 12 morgen : System IV
5 D.	: 24 sheep to 24 morgen : System V.

Experiments 1 L, 2 L, 3 L, 3 D, 4 D and 5 D were commenced in February 1946 and discontinued in July 1953. Experiments 4 L and 5 L were started in February 1950 while experiments 1 D and 2 D were initiated in August 1950. These four experiments were stopped in February 1957, when preparations were made for the launching of a new series of experiments.

Veld and sheep interaction was measured by means of

(1) Plant counts and frequency estimates,

(2) Field observations,

(3) Soil analysis,

(4) Liveweight changes,

(5).../129

(5) Liveweight-curve area, and

(6) Geigeria-poisoning and other losses.

(1) PLANT COUNTS:

In Tables XXXVIII and XXXIX the change in plant counts and frequencies during the experimental period is given for lime and dolomiteveld respectively.

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TABLE XXXVIII.

PLANT RESPONSE TO FIVE GRAZING SYSTEMS WITH SHEEP ON LIMEVELD AT KOOPMANSFONTEIN.

Number of Quadrats:	Number of plants in (n) 15 quadrats.						Frequency per (s) quadrats. 60		300	
	Expt. 1 L. Syst. I		Expt. 2 L. Syst. II		Expt. 3 L. Syst. III		Expt. 4 L. Syst. IV		Expt. 5 L. Syst. V	
	1947	1953	1947	1953	1947	1953	1951	1957	1951	1957
CLIMAX SPECIES:										
Themeda triandra.....	51	15	38	36	34	27	6	0■	17	9■
Fingerhuthia africana.....	45	4	40	3	28	4	2	0	29	3■
Chrysopogon montanus.....	15	39	1	0	40	15	2	1	14	28■
Sporobolus fimbriatus.....	10	50	36	11	1	1	9	9	1	2
Eustachys paspaloides.....	9	1	9	2	15	0	0	0	20	1■
Digitaria eriantha.....	8	0	10	0	21	0	6	5	10	5
Cymbopogon plurinodis.....	3	2	0	0	3	0	0	0	12	16
Aristida vestita.....	0	0	3	2	0	0	0	0	1	0
A. uniplumis.....	0	0	0	0	0	0	0	0	1	2
Panicum coloratum.....	0	0	0	54	0	0	0	0	0	0
Sub-total	141	111	137	106	146	47				
SUCCESSIONAL SPECIES:										
Eragrostis lehmanniana.....	144	105	44	51	43	155	3	8	49	210■
E. denudata.....	0	64	0	0	0	0	0	1	0	1
Enneapogon scoparius.....	0	0	0	0	0	4	0	0	0	0
Cropetium capense.....	0	24	0	12	0	0	20	29	59	159■
Tragus koelerioides.....	19	2	10	0	14	0	0	0	21	4
Sub-total	163	195	54	63	57	159				
PIONEER SPECIES:										
Enneapogon brachystachyus....	58	2152	42	1417	30	291	21	38■	115	158■
Tragus racemosus.....	0	131	33	373	24	150	27	16	62	34■
Aristida curvata.....	0	15	1	5	4	1	24	31	66	88■
Sub-total	58	2298	76	1795	58	442				
WEEDS:										
Geigeria africana.....	29	204	9	324	1	187	18	48■	116	229■
Tribulus terrestris.....	1	64	4	33	4	14	0	2	0	3
Chrysocoma tenuifolia.....	0	1	0	0	0	0	2	4	6	11
Sub-total	30	269	13	357	5	201				
KARROID SPECIES:										
Monechma divaricatum.....	8	3	0	4	0	0	0	0	0	4
Aster muricatus.....	1	4	11	1	0	1	3	1	2	26■
Indigofera patens.....	0	1	0	1	0	0	0	0	2	2
Sub-total	9	8	11	6	0	1				
OTHER SPECIES:										
Woody.....	0	30	6	29	1	1	0	0	1	1
Herbaceous.....	82	198	14	66	15	48	34	36	218	230
Sub-total	82	228	20	95	16	49				
GRAND TOTAL.	483	3109	311	2422	282	899				

Woody species comprise the genera Euclea, Maytenus, Tarchonanthus, Pterothrix and Rhus.

Herbaceous species comprise the genera Limeum, Barleria, Stachys, Atriplex and Sericorema.

■ = Significant difference at P = 0.05.

■■ = Significant difference at P = 0.01.

(s) = Surveys according to the method by Von Broembsen (1951).

(n) = Surveys according to the method of Raunkiaer as described by Murray (1946).

PLANT RESPONSE TO FIVE GRAZING SYSTEMS WITH SHEEP ON DOLOMITEVELD AT KOOPMANSPOORT.

	Frequency per 180 quadrats.(a)				Number of plants per 15 quadrats.(n)		Frequency per 300 quadrats.(a)			
	Expt. 1 D.		Expt. 2 D.		Expt. 3 D.		Expt. 4 D.		Expt. 5 D.	
	Syst. I		Syst. II		Syst. III		Syst. IV		Syst. V	
	1951	1957	1951	1957	1947	1953	1947	1953	1951	1957
CLIMAX SPECIES:										
Digitaria eriantha	18	10	23	52**	69	74	17	35	52	67
Chrysopogon montanus	8	13	20	18	16	15	14	40	13	9
Heteropogon contortus	66	47*	73	52*	14	1	50	7	8	3
Sporobolus fimbriatus	0**	7	10	7	0	0	0	4	2	1
Cymbopogon plurinodis	0	2	0	3	0	0	1	0	1	0
Themeda triandra	3	5	5	7	12	8	2	4	1	0
Enthophora pubescens	0	0	0	0	0	0	0	0	1	0
Aristida unipiumis	18	13	0	0	0	0	0	0	0	0
Panicum coloratum	0*	5	3	0	0	0	0	0	0	0
Fingerhuthia africana	3	0	0	0	1	0	22	0	0	0
Aristida vestita	5	13	0	0	0	0	5	4	0	0
Eustachys paspaloides	0	0	0	0	0	0	5	1	0	0
Sub-total					112	98	126	95		
SUCCESSIONAL SPECIES:										
Eragrostis lehmanniana	158	270**	123	267**	48	627	68	463	139	206**
E. echinocloidos	0	0	0	0	0	0	0	0	0	4
E. denudata	0	23**	0	5	30	12	43	95	112	115
Tragus koelerioides	0	0	0	0	19	0	1	0	0	0
Oropetium capense	20	70**	15	73**	0	187	0	0	41	130
Cynodon dactylon	0	0	4	4	0	0	0	0	0	0
Enneapogon scoparius	10	3*	15	15	11	11	42	47	18	18
Pogonarthia squarrosa	0	0	0	0	0	0	0	0	7	0**
Sub-total					108	837	154	605		
PIONEER SPECIES:										
Enneapogon brachystachyus	15	35**	58	93**	50	448	15	333	7	21**
Aristida curvata	12	3*	3	25**	15	16	12	15	24	0**
A. congesta	0	15**	0	2	0	0	0	0	1	43**
Tragus racemosus	13	8	13	20	58	665	24	224	25	18
Sub-total					123	1129	51	572		
WEEDS:										
Geigeria africana	42	77**	32	83**	1	61	6	84	11	18*
Chrysocoma tenuifolia	27	10**	28	13	1	3	5	2	7	1
Tribulus terrestris	0	0	0	3	14	29	4	17	0	0
Ornithoglossum glaucum	0	0	0	0	0	0	0	0	0	1
Sub-total					16	93	15	103		
KARROID SPECIES:										
Indigofera patens	2	3	0	8**	0	0	0	0	2	1
Aster muricatus	0	2	0	8**	3	10	0	0	2	0
Sub-total...					3	10	0	0		
					6	20	0	0		
OTHER SPECIES:										
Woody	5	3*	12	3*	11	7	10	16	3	4**
Herbaceous	25	233**	28	202**	28	55	12	36	34	130**
Sub-total					39	62	22	52		
GRAND TOTAL					404	2229	358	1427		

Woody species comprise the genera Rhus, Tarchonanthus, Royena, Asparagus, Euclea, Enretia and Lycium.
Herbaceous species comprise the genera Barleria, Atriplex, Sericorema, Pharnaceum, Walafrida, Oxalis, Cyperus, Hibiscus, Hermannia, Monsonia, Limeum, Urginea, Scilla, Sesamum and Stachys.

* = Significant difference at P = 0.05
** = Significant difference at P = 0.01

(a) = Surveys according to the method by Van Broembsen (1951).
(n) = Surveys according to the method by Raunkiaer as described by Murray (1946).

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	1951	1957	1951	1957	1947	1953	1947	1953	1951	1957
CLIMAX SPECIES:										
Digitaria eriantha.....	18	10	23	52**	69	74	17	35	52	67
Chrysopogon montanus.....	8	13	20	18	16	15	14	40	13	9
Heteropogon contortus.....	66	47*	73	52*	14	1	50	7	8	5
Sporobolus fimbriatus.....	0**	7	10	7	0	0	0	4	2	1
Cymbopogon plurinodis.....	0	2	0	3	0	0	1	0	1	0
Themeda triandra.....	3	5	5	7	12	8	2	4	1	0
Tetrapogon pubescens.....	0	0	0	0	0	0	0	0	1	0
Aristida uniplumis.....	18	13	0	0	0	0	0	0	0	0
Panicum coloratum.....	0*	5	3	0	0	0	0	0	0	0
Pingerhuthia africana.....	3	0	0	0	1	0	22	0	0	0
Aristida vestita.....	5	13	0	0	0	0	5	4	0	0
Eustachys paspaloides.....	0	0	0	0	0	0	5	1	0	0
Sub-total					112	98	126	95		
SUCCESSIONAL SPECIES:										
Eragrostis lehmanniana.....	158	270**	123	267**	48	627	68	463	139	206**
E. echinocloidea.....	0	0	0	0	0	0	0	0	0	4
E. denudata.....	0	23**	0	5	30	12	43	95	112	115
Tragus koelerioides.....	0	0	0	0	19	0	1	0	0	0
Uropetium capense.....	20	70**	15	73**	0	187	0	0	41	130
Cynodon dactylon.....	0	0	4	4	0	0	0	0	0	0
Enneapogon scoparius.....	10	3*	15	15	11	11	42	47	18	18
Pogonarthia squarrosa	0	0	0	0	0	0	0	0	7	0**
Sub-total					108	837	154	605		
PIONEER SPECIES:										
Enneapogon brachystachyus.....	15	35**	58	93**	50	448	15	333	7	21**
Aristida curvata.....	12	3*	3	25**	15	16	12	15	24	0**
A. congesta.....	0	15**	0	2	0	0	0	0	1	43**
Tragus racemosus.....	13	8	13	20	58	665	24	224	25	18
Sub-total					123	1129	51	572		
WEEDS:										
Geigeria africana.....	42	77**	32	83**	1	61	6	84	11	18*
Chrysocoma tenuifolia.....	27	10**	28	13	1	3	5	2	7	1
Tribulus terrestris.....	0	0	0	3	14	29	4	17	0	0
Ornithoglossum glaucum.....	0	0	0	0	0	0	0	0	0	1
Sub-total					16	93	15	103		
KARROID SPECIES:										
Indigofera patens.....	2	3	0	8**	0	0	0	0	2	1
Aster muricatus.....	0	2	0	8**	3	10	0	0	2	0
Sub-total...					3	10	0	0		
					6	20	0	0		
OTHER SPECIES:										
Woody.....	5	3	12	3*	11	7	10	16	3	4
Herbaceous.....	25	233**	28	202**	28	55	12	36	34	130**
Sub-total					39	62	22	52		
GRAND TOTAL					404	2229	368	1427		

Woody species comprise the genera Rhus, Tarchonanthus, Royena, Asparagus, Euclea, Ehretia and Maytenus.
Herbaceous species comprise the genera Barleria, Atriplex, Sericorema, Pharnaceum, Walafrida, Oxalis, Cyperus, Hibiscus, Hermannia, Monsonia, Linum, Urginea, Scilla, Sesamum and Stachys.

* = Significant difference at P = 0.05
** = Significant difference at P = 0.01

{s} = Surveys according to the method by Von Broembsen (1951).
{n} = Surveys according to the method by Raunkiaer as described by Murray (1946).

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Because of the inadequacy of the method of plant counts, large changes in the botanical composition only will be considered.

On both veld types, Themeda triandra, except under continuous grazing on lime, Chrysopogon montanus, Sporobolus fimbriatus and Digitaria eriantha, except under the three-camp systems on lime, proved tolerant to grazing by sheep under the different systems of management at the rate of one sheep per morgen. Under all conditions Fingerhuthia africana, Tragus koelerioides and Eustachys paspaloides proved to be intolerant to grazing, while Heteropogon contortus, Cymbopogon plurinodis and Enneapogon scoparius were kept in check.

The control of Chrysocoma tenuifolia was affected under all systems of grazing and on both veld types. High seasonal variation in the occurrence of Geigeria africana does not warrant inferences to be drawn from the plant counts of two isolated seasons only. From the plant response point of view, there is little to choose between the different systems used.

(2) FIELD OBSERVATIONS:

Eragrostis lehmanniana producing new leaves from both tufts and nodes, and Themeda triandra were the first grasses to sprout in spring. They were followed by Fingerhuthia africana, Chrysopogon montanus, Cymbopogon plurinodis and others, Digitaria eriantha being the last to green up after winter. Out-of-season winter or spring rains resulted in vigorous sprouting followed by active growth as soon as temperatures rose after winter.

On summer-used camps, grasses intolerant to grazing sprouted with less vigour compared with grasses in camps that were grazed at other times of the year. During mild winters with abundant carry-over of moisture, either from autumn or winter rains, the vegetation remained active throughout winter. Summer-grazed camps sprouted earlier than was the case with summer-rested camps, but sprouts on the former camps lasted for a short while only compared

with.../133

with long continued sprouting on summer-spared camps. Cymbopogon was the most vigorous grass to sprout and continued to do so for an appreciable time. With new shoots of this species emerging from old tufts, sheep grazed these shoots from in among mature and dry stems and leaves.

Only in the case of other species being available did sheep discriminate against Cymbopogon, Sporobolus, Heteropogon contortus, Aristida vestita, Digitaria eriantha, Enneapogon scoparius and stems of all grasses. E. lehmanniana, Themeda, Tragus koelerioides and Fingerhuthia were preferred above all others. In early summer, sheep grazed A. curvata and prevented it from seeding. At this time also, sheep readily took all the grasses with no sign whatsoever of either species or area-selective grazing. Upon entering a camp in midsummer sheep preferred grazing grass leaves to stems and inflorescences. In winter sheep experienced difficulty in utilizing the rank growth on all-summer spared camps.

On lime with abundant Tarchonanthus minor available, sheep browsed this species in preference to T. camphoratus var. litakunensis, Rhus ciliata, R. pyroides, R. lancea, Grewia cana, Euclea ovata, Zizyphus mucronata and Royena hirsuta. On dolomite however, no such preferences were evident.

In winter and autumn sheep relinquished grasses in favour of shrubs. Sheep persisted for some time in browsing shrub even after the occurrence of the first summer rains and before grass became abundantly available. In years of high rainfall sheep took to shrubs earlier than in normal or in dry seasons, in which case grasses were grazed off first. Severe and extended browsing of both leaves, twigs and branches caused shrub to recover slowly after drought; in fact, in some cases no recovery took place. When undisturbed by stock, new shoots grew up to two feet in a single growing season.

Geigeria africana survived moist and mild winters and provided the only green in overgrazed camps during spring. In all-summer

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grazed camps, G. africana appeared more vigorous and more numerous than in camps grazed during other seasons. In such camps, even the annual grasses, normally not readily taken by sheep, were short cropped.

Themeda particularly favoured the crumbly lime soil on the shoulders of pans and depressions, seldomly occurring inside them. Sporobolus was found more abundantly on the southern- and south-eastern sides of bushes and bush-clumps. Chrysopogon was confined mainly to rock outcrops or surface limestone, Enneapogon brachystachyus to bare soil among rocks and Aristida curvata and Tragus racemosus to deeper soil in pans and along temporary watercourses. In these, G. africana seldomly occurred, this species rather preferring sites with only a thin film of soil.

Cenchrus ciliaris occurred in a few bush-sheltered habitats on dolomite only. It was preferred above all other grasses in spring and grazed with avidity at other times. This species remained green well into winter and as soon as warmer weather set in, it became active, stems turning green and new leaves emerging from the nodes.

All-summer grazing impaired the vigour of tuft grasses, but after an all-summer rest it was fully restored. Shrub recovered well after two consecutive summer rests. Resting of camps in either early or late-summer under normal rainfall conditions, proved too short a time to allow for seeding. A full summer rest was required in such seasons, while during years with abundant summer rainfall, half-a-season sufficed.

Utilization for half-a-summer, or in either spring or autumn, left some form of ground cover, while all-summer use at this rate of stocking, left a camp bare. On limeveld, the grazing pressure under all systems was of such an order that by the middle of winter, all grasses were cropped short. Sheep would then commence browsing shrubs, returning in spring to new, emerging shoots, and continuing this process until the onset of summer rains.

Under none of the grazing systems were camps ever left as bare

on.../135

on dolomite as on limeveld. In case of dolomite, the intensity of grazing appeared to be in harmony with the production of herbage. In fact, in the case of systems I, II and V the impression was sometimes gained that the veld was possibly understocked.

(3) SOIL ANALYSIS:

In Tables XL and XLI particulars are given of mechanical and chemical analyses of soils derived from experiments on lime and dolomiteveld respectively, after being exposed to the different grazing systems for the duration of these experiments.

TABLE XL...../136

TABLE XL.

MECHANICAL AND CHEMICAL ANALYSES (a) OF LIMEVELD SOILS UNDER FIVE GRAZING SYSTEMS WITH SHEEP AT KOOPMANSFONTEIN.

	Expt.1L-System I			Expt.2L-System II			Expt.3L-System III			Expt.4L-System IV			Expt.5L-System V		
Soil horizon (inches).	0-3	3-6	6-12	0-3	3-6	6-12	0-3	3-6	6-12	0-3	3-6	6-12	0-3	3-6	6-12
pH.	7.40	7.48	7.02	7.57	7.53	7.44	7.47	6.79	6.68	7.35	6.85	6.83	7.33	7.48	6.72
Resistance at 60°F.	1380	1290	1320	1550	1320	1270	1380	1850	1100	1150	1520	1490	1260	1530	1720
Mechanical analysis (%):															
Sand (>0.02 mm.)	85.19	84.05	75.03	84.32	84.71	84.44	84.57	84.39	80.43	80.39	83.41	82.65	84.40	85.07	84.41
Silt (0.02 - 0.002 mm.)	6.94	6.28	6.89	7.62	4.88	3.99	5.59	4.58	3.89	8.83	5.35	4.51	6.35	6.75	4.86
Clay (<0.002 mm.)	7.87	9.67	18.08	8.06	10.41	11.57	9.84	11.03	15.68	10.78	11.24	12.84	9.25	8.18	10.73
$CaCO_3$(%).	1.32	0.46	0.00	1.81	0.30	0.00	0.43	0.00	0.00	0.09	0.00	0.00	0.00	0.14	0.00
P. (%) (z)	.0036	.0021	.0006	.0030	.0011	.0007	.0030	.0009	.0005	.0025	.0006	.0003	.0012	.0023	.0004
C. (%)	1.25	1.04	0.75	0.95	0.78	0.74	1.05	0.84	0.66	0.93	0.60	0.47	0.83	0.84	0.47
N. (%)	0.12	0.10	0.08	0.11	0.08	0.06	0.12	0.09	0.05	0.11	0.07	0.05	0.09	0.11	0.06
C : N ratio.	10.5:1	10.3:1	10.0:1	8.6:1	9.6:1	12.8:1	9.1:1	9.1:1	14.7:1	8.8:1	8.8:1	10.2:1	9.2:1	7.4:1	8.0:1
Water-soluble salts (%) (n):															
Na.	.0011	.0011	.0012	.0011	.0010	.0012	.0013	.0008	.0010	.0011	.0019	.0009	.0010	.0010	.0010
K.	.0011	.0005	.0009	.0013	.0005	.0003	.0013	.0013	.0007	.0007	.0003	.0002	.0011	.0010	.0007
Ca.	.0052	.0048	.0030	.0046	.0048	.0048	.0052	.0026	.0050	.0037	.0041	.0028	.0031	.0035	.0026
Mg.	.0001	.0002	.0005	.0005	.0007	.0004	.0001	.0001	.0004	.0012	.0006	.0017	.0007	.0003	.0001
HCO_3.	.0136	.0144	.0095	.0138	.0154	.0141	.0142	.0074	.0142	.0115	.0109	.0105	.0109	.0097	.0090
Cl.	.0024	.0021	.0030	.0027	.0027	.0038	.0038	.0035	.0027	.0024	.0030	.0024	.0027	.0024	.0021

(a) = Analyses by D.F.M. Claassen.

(z) = 1% Citric acid solution.

(n) = Soil : Water :: 1 : 2.

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In general, soils are slightly more alkaline, the clay fraction increases and the silt fraction and phosphorus content decrease with increasing depth. Considering the upper horizon only, respectively the highest and lowest sand fraction, and phosphorus, carbon and nitrogen contents, and also the ratio of carbon to nitrogen, were recorded under system I on the one hand and system IV on the other hand. In the case of clay, system I recorded the least and system IV the highest fraction.

TABLE XLI../138.

TABLE XLI

MECHANICAL AND CHEMICAL ANALYSES(s) OF DOLOMITEVELD SOILS UNDER FIVE GRAZING SYSTEMS WITH SHEEP AT KOOPMANSFONTEIN.

Soil horizon (inches).	Expt.1 D-System I			Expt.2 D-System II			Expt.3 D-System III			Expt.4 D-System IV			Expt.5 D-System V		
	0-3	3-6	6-12	0-3	3-6	6-12	0-3	3-6	6-12	0-3	3-6	6-12	0-3	3-6	6-12
pH.	7.42	7.38	7.55	7.50	7.03	7.42	7.24	7.30	6.93	7.40	7.48	7.55	6.70	7.07	7.28
Resistance at 60°F.	1280	1080	1060	1200	1260	990	1240	1260	1530	1200	1050	1150	1700	1160	1230
Mechanical analysis (%):															
Sand (>0.02 mm.)	80.55	79.12	78.42	82.54	78.61	79.91	82.92	81.82	82.64	81.02	82.11	81.20	83.35	80.92	82.74
Silt (0.02 - 0.002 mm.)	6.68	5.14	5.49	5.55	5.81	4.37	5.24	4.95	3.76	9.85	8.12	6.41	6.75	6.90	5.02
Clay (<0.002 mm.)	12.77	15.74	16.09	11.91	15.58	15.72	11.48	13.23	13.60	9.18	9.77	12.39	9.90	12.18	12.24
$CaCO_3$.(%)	0.34	0.11	0.55	0.47	0.00	0.00	0.00	0.00	0.00	1.71	0.72	0.22	0.00	0.00	0.00
P. (%) (z)	.0033	.0019	.0027	.0026	.0010	.0015	.0021	.0011	.0006	.0036	.0033	.0019	.0019	.0011	.0012
C. (%)	0.93	0.77	0.50	0.87	0.74	0.59	0.92	0.81	0.44	1.67	1.16	0.60	0.80	1.01	1.16
N. (%)	0.11	0.09	0.07	0.11	0.07	0.06	0.10	0.08	0.05	0.15	0.13	0.07	0.07	0.07	0.09
C : N ratio.	8.9:1	8.5:1	7.6:1	8.0:1	10.7:1	9.2:1	9.7:1	10.0:1	8.8:1	11.0:1	8.8:1	8.2:1	10.8:1	13.6:1	13.6:1
Water-soluble salts (%) (n):															
Na.	.0013	.0012	.0010	.0014	.0006	.0007	.0011	.0009	.0009	.0009	.0010	.0010	.0009	.0009	.0009
K.	.0012	.0007	.0003	.0011	.0004	.0003	.0015	.0006	.0005	.0012	.0011	.0003	.0012	.0004	.0003
Ca.	.0048	.0031	.0035	.0052	.0028	.0050	.0037	.0039	.0022	.0057	.0054	.0015	.0031	.0028	.0028
Mg.	.0004	.0003	.0004	.0002	.0004	.0006	.0008	.0004	.0005	.0002	.0008	.0024	.0003	.0002	.0007
HCO_3.	.0156	.0113	.0118	.0156	.0092	.0172	.0131	.0123	.0074	.0156	.0148	.0141	.0067	.0074	.0107
Cl.	.0021	.0024	.0024	.0027	.0021	.0024	.0035	.0041	.0032	.0038	.0044	.0038	.0056	.0032	.0035

(s) = Analyses by D.F.M. Claassen.

(z) = 1% Citric acid solution.

(n) = Soil : Water :: 1 : 2.

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The clay fraction of these soils increases while the silt fraction decreases with increasing depth of soil. Phosphorus, carbon and nitrogen are generally higher in the upper soil horizons than in the lower layers. The sodium, calcium and potassium contents of these soils follow the same trend. Considering the 0-3 inch soil horizon only, the highest acidity, sand fraction and chlorine content, and among the highest carbon to nitrogen ratios on the one hand, and the lowest phosphorus, carbon, nitrogen, sodium, calcium and bicarbonate content were recorded from soils under the five-camp system. Soil from continuous grazing were highest in silt, phosphorus, carbon, nitrogen, carbon-nitrogen ratio, calcium and bicarbonate content, and lowest in clay.

(4) LIVEWEIGHTS:

In Tables XLII and XLIII liveweight particulars are given for sheep grazing lime and dolomiteveld under five different systems of grazing management.

TABLE XLII../140

There is little to choose between the various systems on limeveld. However, system III resulted in the highest summer gain and also the most severe spring loss. System I led to the highest net gain and total digestible nutrients obtained, while the poorest net gain occurred under system II and the lowest total digestible nutrients under system V. Continuous grazing gave the best liveweight maintenance per morgen with among the lowest total digestible nutrient production.

On dolomite, continuous grazing led to the best summer gains, the lowest spring losses and the highest net gain, maintenance and total digestible nutrients production. There is not much to choose between the other systems.

Of the experiments in existence during the 1948/49 drought, none were able to support their stock; limeveld experiments were the first to fail, followed by systems III, IV and V on dolomite. Continuous grazing failed first in the 1952/53 season and system I later. The other systems supported their animals throughout the period.

No gradual falling off, nor an increasing tendency in liveweight gains, is evident among any of the systems.

(5) AREA OF THE LIVEWEIGHT-CURVE:

In Tables XLIV and XLV the area of the liveweight-curves for experiments on lime and dolomiteveld respectively are given.

TABLE XLIV .../143

TABLE XLIV

AREA(n) BELOW THE LIVEWEIGHT-CURVE OF SHEEP GRAZING LIMEVELD UNDER FIVE GRAZING MANAGEMENT SYSTEMS.

Period on Experiment.	Area of the liveweight-curve. Expt.1 L. System I	Expt.2 L. System II	Expt.3 L. System III	Expt.4 L. System IV	Expt.5 L. System V
5.2.46-25.5.48.	3150	3424	3066	-	-
26.5.48-14.8.51.	3295	3092	3475	-	-
16.8.51-15.7.53.	1507	1585	1538	-	-
28.2.50-17.6.52.	-	-	-	2625	2494
18.6.52-12.7.55.	-	-	-	3085	3041
13.7.55-19.2.57.	-	-	-	1142	1191

H*	Calculated values of z: 1L/2L	2L/3L	1L/3L	4L/5L	Calculated values of P: 1L/2L	2L/3L	1L/3L	4L/5L	Significant Differences P≤ 0.010.
43.99	4.86	6.29	1.88	-	<0.001	<0.001	0.030	-	2 L>1 L; 3 L.
11.68	1.85	3.02	1.60	-	0.032	0.002	0.055	-	3 L> 2 L.
1.58	-	-	-	-	-	-	-	-	N.S.
-	-	-	-	1.50	-	-	-	0.067	N.S.
-	-	-	-	0.37	-	-	-	0.356	N.S.
-	-	-	-	1.90	-	-	-	0.029	N.S.

(n) = The area of the liveweight-curve was calculated from the average liveweight of 10, 10, 10, 12 and 24 sheep for Experiments 1 L, 2 L, 3 L, 4 L and 5 L respectively.

* = H requirement = 9.21 at P = 0.010 (2 D.F.)

N.S. = Not significant.

In the first period only did system II result in a significantly larger liveweight-curve area than either systems I and III. In the second period system III resulted in a significantly larger liveweight-curve area as compared to system II. For the third and subsequent periods no significant differences were established between either systems I, II and III on the one hand or systems IV and V on the other hand.

TABLE XLV..../ 145

In the first period continuous grazing resulted in a significantly larger liveweight-curve area than either systems III and V. In the last period, system I resulted in a larger liveweight-curve area than system IV. During none of the other periods were significant differences in liveweight-curve areas established between systems.

(6) GEIGERIA-POISONING AND OTHER DEATHS:

No "vermoersiekte" occurred on dolomiteveld experiments. However, one sheep was lost to hydrocyanic-poisoning under system II, while two sheep were lost under continuous grazing, three sheep under system II and four sheep under system V as a result of poverty. No losses occurred among sheep grazed according to systems I and III.

On limeveld, Geigeria-poisoning caused the death of one sheep under system I, one sheep in system III, two sheep where veld was continuously grazed and the loss of four sheep under system V. Hydrocyanic-poisoning occurred twice under system II.

Poverty losses were appreciable. System III accounted for one sheep, continuous grazing for eleven and the five-camp system for fourteen deaths.

During the 1947/48 season camp changes during a Geigeria-poisoning outbreak soon cured sheep. In later years a change of camp neither helped in curing or preventing "vermoersiekte" nor in abating the incidence of poverty losses.

DISCUSSION:

A general decline in climax grasses and a corresponding increase in the abundance of seral, weed and herbaceous species, particularly Eragrostis lehmanniana and Enneapogon brachystachyus in all cases and Oropetium capense and Tragus racemosus less generally suggests a rearrangement of species towards a biotic sub-climax under sheep grazing. This condition is similar to that of veld under cattle grazing.

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The intolerance to grazing shown by Fingerhuthia africana and Eustachys paspaloides, and the ability of Themeda triandra, Chrysopogon montanus, Sporobolus fimbriatus and Digitaria eriantha to withstand use, agrees closely to the tolerance exhibited by these species under cattle grazing.

The small dissimilarities in plant response between the different systems might be ascribed to the overruling importance of moisture, which proved an equalizing environmental factor of the greatest magnitude. Speidel (1952) claims that moisture is able to mask the effects of other factors. Biddiscombe, Hutchings, Edgar and Cuthbertson (1956) found that autumn and spring deferment in New South Wales, as against continuous grazing, had a negligible effect on the density or basal area of species constituting the sward. Roe, Southcott and Turner (1959), in an investigation of the native pastures also in New South Wales, found insignificant differences between continuously and rotationally grazed veld, both as regards botanical composition and pasture production.

The control of Chrysocoma tenuifolia effected was most encouraging and might have been a consequence of the greater use sheep made of this plant. By continually defoliating and browsing of growing points at stem apices, sheep succeeded in keeping Chrysocoma short, thereby preventing it from prolific seeding and in that way arresting its increase.

The preference of sheep for grass leaves is probably because of a higher protein content in the leaves than in stems. Henrici (1940) found green leaves of Themeda triandra under Fauresmith conditions to contain nearly twice as much, and brown leaves slightly more protein than the haulms. Cook, Cook and Harris (1948) also found sheep preferred grazing leaves to stems on all types of grazing in Utah and in all seasons. Although stems were found to be twice as abundant as leaves, these workers found stems comprised only 44 per cent of the ingested herbage.

The heavier browsing of shrub by sheep and relinquishing of

grasses.../148

grasses in autumn and winter may be ascribed to lower protein in grasses at this time as compared to shrubs. Henrici (1940) found Tarchonanthus minor contained over 12 per cent protein in autumn and winter as against 8.7 per cent protein for green leaves and 5.4 per cent protein for haulms of Themeda triandra. Cook et al (1948) found the utilization of grasses decreased and the use of browse plants increased as the season advanced.

Vigorous sprouting of Cymbopogon plurinodis is attributable to this species never being overgrazed in summer and autumn and as a consequence its vigour was unimpaired in spring. The introduction of cattle along with sheep to make better use of all produced herbage seems to be called for. The difficulty with which sheep utilized herbage in all-summer rest camps, particularly when they commenced grazing such camps in midwinter, is due to the inability of this class of animal to thrive on the grown-out and frosted-over, rank growth of grasses.

The survival of Geigeria through winter thereby providing early green herbage in spring could easily be a contributory cause of "vermeersiekte". This is of particular concern on overgrazed veld where little other green herbage is available in spring. In such veld, sheep were obliged to graze Geigeria. In this connnection Costello (1957) maintains that the range is probably more subject to imbalance than any other natural community owing to the likelihood of it becoming overgrazed and eroded.

The observational evidence that Geigeria favoured sites with only a thin film of soil may be because of its seeds being churned up by trampling of sheep on deeper soil sites. The resulting incorporation of seeds in the soil may have hampered germination. On the shallow soils seeds remained on the soil and germination was most favourable, providing large populations. Van der Schijff (1948) confirms this in that he found seeds of Geigeria passerinoides syn. africana germinated best when not covered by a film of soil.

The persistent removal of new growth from climax grasses was

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undoubtedly a contributory cause of their decline. The relative scarcity of Cenchrus ciliaris and its failure to increase over twelve years rules out this species from ever becoming of more than local interest in veld management.

Sheep production from the various systems on limeveld did not differ appreciably. The investigations of Biddiscombe et al (1956) at Trangie in New South Wales led to a similar result. These workers found deferred grazing, when compared with continuous grazing, to have little effect on available feed, wool production or bodyweight. Contrary to these results, Dickson (1959) found rotational grazing superior at very high stocking rates when feed supply became the major limitation. It is possible that the grazing rate of one morgen per sheep used in these experiments was not sufficiently severe for differences between systems, similar to those obtained by Dickson (loc.cit), to show up.

On rotationally grazed dolomiteveld, sheep liveweight gains, in four out of eight seasons, were below that of sheep on continuously grazed veld, agreeing with results obtained by Dickson(1959) already mentioned and by Roe et al (1959) who found the mean liveweight of sheep on rotationally grazed veld to be consistently below that of sheep on continuously grazed veld.

From the results in general it must be deduced that, regarding production from sheep, very little difference existed between the various systems in existence.

Significance can not be attached to dates of removal of stock from the experiments in times of herbage shortage. Sheep from system IV were removed in November 1952 when 15 pounds of net gain were still to their credit, while sheep from system I were removed more than two months later when their net gains amounted to 12 pounds. For dates of removal to have significance, sheep under system IV should have remained on the experiments until they fell to the 12 pound gain level. Or conversely, sheep from system I should have been removed much earlier, at the time when their net gain dropped

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to 15 pounds. The same reasoning applies in the case of dolomiteveld experiments. Sheep under system III should have been removed earlier than 26th October 1949, or vice versa, sheep from systems IV and V should have been kept on the veld until they in turn fell to 11 pounds net gain.

Death losses on dolomiteveld were few and only those occurring under system V need explaining. Of all the systems, on both lime and dolomiteveld, poverty losses were most numerous under system V. The reason for this is not at all clear, but it might have been due to the slow rotation according to which sheep were transferred twice a year only. In the dormant season this took place in midwinter when sheep were unable to utilize the dry, tall and rank growth. It must be borne in mind that system V was devised by Irvine (1941) primarily for cattle under Transvaal bushveld conditions. Among others, Whitmore (1951) found winters in the bushveld to be relatively frost-free. Curing of grasses as standing hay would thus be possible and herbage would still be acceptable to cattle from midwinter onwards. In contrast to this, severe frosts occur at Koopmansfontein. From the middle of May to September this tended to make the already dry grasses less acceptable to cattle and even more so to sheep.

The large number of sheep lost as a result of poverty as against only one-quarter as many from Geigeria-poisoning, of which six were ewes, suggests that poverty is by far the more important factor to consider.

The main conclusion to be drawn from these grazing system experiments is that there is little to be gained from rotation grazing systems as opposed to continuous use of veld. The cost of an additional two or more fences does not appear to be justified. Provision for spring in the form of short, spared veld and a fair amount of Tarchonanthus minor within easy reach of sheep, seem to meet the requirements of both vegetation and stock. Cattle, being lighter browsers than sheep, appear to be essential to provide shorter herbage,

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more acceptable to sheep.

It must, however, be said by way of caution, that these experiments were executed over a relatively short period and that the full effect of continuous grazing on the vegetation may take some time to manifest itself. A two-camp rotational grazing system whereby camps are alternately grazed and rested for the full growing period, while both are utilized in the dormant season, is suggested. Spared veld and leafy T. minor could then be made available to sheep in spring and only one additional fence would be required.

ANNEXURE 8.../152

CHAPTER V.

THE EFFECT OF GRAZING INTENSITY, ROTATIONAL GRAZING AND RATIO OF LARGE TO SMALL STOCK ON CATTLE AND SHEEP PRODUCTION.

It is customary for farmers who keep both cattle and sheep on the Ghaap plateau, to breed these animals indiscriminately and with little regard to their numbers, their ratios to one another or the way in which they are grazed. The ratio of large to small stock usually depends on the prices realized for the products of either cattle or sheep and not on the ecological potential of the vegetation. Little attention is given to veld management for maximum production on a sustained basis. During droughts and during spring many cattle die from poverty, and "vermeersiekte" among sheep is rife, both in spring and in autumn.

The available herbage includes both shrubs, tall grasses and grasses and herbs of short stature. Farming with only one kind of stock does injustice to the available grazing. Sheep discriminate against tall grasses and consequently shrubs are severely browsed. When cattle alone are kept much of the shorter herbage is not grazed or is only used with difficulty.

It was thought that a combination of both large and small stock would utilize the available herbage more efficiently. These considerations gave rise to three series of experiments, in which both steers and wethers were grazed on the veld to compare:-

A. Three grazing intensities, employing grazing system VI at a ratio of one beast to four sheep;

B. Three grazing systems at the stocking rate of one unit to twelve morgen, units being one beast and one sheep and one one beast and four sheep; and

C. Five ratios of large to small stock, grazed according to grazing systems VI and VII, and at two stocking rates.

The purpose of these experiments was to determine what may be regarded as a s..e grazing intensity and ratio of large to small

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stock. Also, to find how veld can be managed so that both classes of stock derive maximum benefit commensurate with veld conservation and improvement.

A. GRAZING INTENSITIES.

The grazing rate experiments were initiated in July 1952 and were terminated in June 1957. They were carried out simultaneously on lime and dolomiteveld. Table XLVI gives details of the six grazing intensity experiments.

TABLE XLVI.

GRAZING INTENSITY WITH CATTLE AND SHEEP ON VELD AT KOOPMANSFONTEIN.

Experiment no.	Particulars.
13 L.	Limeveld : One grazing (x) unit to 9 morgen.
14 L.	: One grazing unit to 12 morgen.
15 L.	: One grazing unit to 15 morgen.
13 D.	Dolomiteveld : One grazing unit to 9 morgen.
14 D.	: One grazing unit to 12 morgen.
15 D.	: One grazing unit to 15 morgen.

(x) = One steer and four sheep constituted a grazing unit.

Veld and livestock interaction was measured by means of

(1) Plant counts,
(2) Field observations,
(3) Soil analysis,
(4) Liveweights,
(5) Area of the liveweight-curve,
(6) Slaughter details of steers, and
(7) Geigeria-poisoning and other losses.

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(1) PLANT COUNTS:

In Tables XLVIIand XLVIII, species frequency, as an indicator of veld change, are given for lime and dolomiteveld respectively.

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TABLE XLVII.

PLANT RESPONSE TO THREE GRAZING INTENSITIES WITH CATTLE AND SHEEP ON LIMEVELD AT KOOPMANSFONTEIN.

	Frequency of Species per 300 quadrats(s)					
	Expt.13 L. 1 Unit/ 9m.		Expt.14 L. 1 Unit/12m.		Expt.15 L. 1 Unit/15m.	
	1951	1957	1951	1957	1951	1957
CLIMAX SPECIES:						
Themeda triandra.....	43	30	9	18	26	45*
Chrysopogon montanus.....	34	27	20	14	47	16**
Digitaria eriantha.....	31	16*	8	10	13	5
Fingerhuthia africana.....	16	6*	16	4**	28	22
Cymbopogon plurinodis.....	6	13	18	22	17	22
Aristida vestita.....	4	2	1	0	1	2
Eustachys paspaloides.....	3	0	5	0	0	2
Sporobolus fimbriatus.....	0	2	29	0**	0	0
Aristida uniplumis.....	0	0	0	0	2	0
SERAL SPECIES:						
Eragrostis lehmanniana.....	82	213**	142	222**	67	175**
E. echinochloidea.....	0	0	0	2	0	0
Cropetium capense.....	45	147**	50	147**	45	132**
Tragus koelerioides.....	26	3**	14	0**	17	1**
PIONEER SPECIES:						
Enneapogon brachystachyus...	153	232**	48	134**	104	100
Aristida curvata.....	55	55	23	36	80	33**
Tragus racemosus.....	33	41	56	3**	60	16**
WEEDS:						
Geigeria africana.....	174	242**	132	207**	98	173**
Chrysocoma tenuifolia.....	0	24**	9	5	4	3
Tribulus terrestris.....	0	7**	0	4	0	3
KARROID SPECIES:						
Indigofera patens.....	1	8*	6	5	0	4
Aster muricatus.....	0	7**	37	62**	0	15**
Monechma divaricatum.....	0	35**	1	16**	0	18**
OTHER SPECIES:						
Woody.....	1	5**	4	2**	0	1*
Herbaceous.....	159	196**	25	145**	184	153**

Woody species comprise the genera Euclea, Rhus and Tarchonanthus.

Herbaceous species comprise the genera Hermannia, Sericorema, Barleria, Walafrida, Euphorbia, Monsonia, Thesium, Stachys, Cyperus, Hibiscus, Commelina, Bulbostylis, Moraea, Oxalis, Pergolettia and Scilla.

* = Significant difference at P = 0.05.

** = Significant difference at P = 0.01.

(s) = Surveys according to the method by Von Broembsen (1951).

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TABLE XLVIII.

PLANT RESPONSE TO THREE GRAZING INTENSITIES WITH CATTLE AND SHEEP ON DOLOMITEVELD AT KOOPMANSFONTEIN.

	Frequency of Species per 300 quadrats(s)					
	Expt.13 D. 1 Unit/ 9m.		Expt.14 D. 1 Unit/12m.		Expt.15 D. 1 Unit/15m.	
	1951	1957	1951	1957	1951	1957
CLIMAX SPECIES:						
Sporobolus fimbriatus.....	41	10**	3	4	7	7
Chrysopogon montanus.....	21	24	22	20	10	7
Digitaria eriantha.....	20	41**	20	13	12	26*
Heteropogon contortus.....	18	5**	2	5	48	57
Themeda triandra.....	1	0	8	4	9	12
Cymbopogon plurinodis.....	1	0	2	1	1	0
Aristida uniplumis.....	0	2	0	0	0	0
Fingerhuthia africana.....	0	1	0	0	5	0*
SERAL SPECIES.						
Eragrostis lehmanniana.....	180	243**	207	219	131	195**
E. obtusa.....	0	21**	0	11**	0	15**
E. echinochloidea.....	0	3	0	13**	0	12**
E. denudata.....	0	0	16	13**	3	1**
Cropetium capense.....	26	145**	165	228**	34	137**
Tragus koelerioides.....	14	1**	0	0	3	0
Enneapogon scoparius.....	5	0*	6	7	16	10
PIONEER SPECIES:						
Enneapogon brachystachyus...	49	51	139	102**	42	87**
Aristida curvata.....	61	57**	70	29**	58	25**
Tragus racemosus.....	73	11**	64	12**	45	11**
WEEDS:						
Geigeria africana.....	10	11	0	20**	8	32**
Chrysocoma tenuifolia.....	29	24	2	8	5	11
Tribulus terrestris.....	1	0	0	1	0	1
KARROID SPECIES:						
Aster muricatus.....	0	2	1	8*	0	4
Indigofera patens.....	2	0	4	4	0	4
OTHER SPECIES:						
Woody.....	6	5**	5	5	3	4
Herbaceous.....	6	11**	11	158**	6	180**

Woody species compriso the genera Asparagus, Euclea and Royena.

Herbaceous species comprise the genera Commelina, Barleria, Oxalis, Euphorbia, Soricerema, Pharnaceum, Hibiscus and Walafrida.

* = Significant difference at P = 0.05.

** = Significant difference at P = 0.01.

(s) = Surveys according to the method by Von Broembsen (1951).

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Because of the inadequacy of the plant counts large changes only in the frequency of species will be considered. Chrysopogon montanus, Digitaria eriantha and Themeda triandra on both veld types and Fingerhuthia africana on lime and Sporobolus fimbriatus on dolomite tolerated grazing by cattle and sheep. The frequency of Cymbopogon plurinodis on lime and Heteropogon contortus on dolomite (except under severe grazing where it declined) remained stable under joint grazing.

A general decrease of climax species, except under light grazing on dolomite, and an increase of seral, weed, karroid and other species took place. Owing to a pronounced degree of seasonal variation in the occurrence of Geigeria africana, no inferences from the plant counts of two seasons only are justified.

Severe grazing resulted in the increase of Chrysocoma tenuifolia on limeveld while under moderate and light grazing the changes were insignificant; on dolomite the incidence of this species remained the same under all grazing intensities. Except for light grazing on dolomite, there is little to choose between the different stocking rates in respect of changes in plant frequency.

(2) FIELD OBSERVATIONS:

Aristida curvata. Eragrostis capense and Tragus racemosus abounded on the flats, in pans and depressions and seldomly occurred in the shade of bushes or among perennial tuft grasses. On dolomite, Geigeria africana was found only on seams of limestone and where lime was to be found near the surface. In sharp contrast to the flats, the ridges and rock outcrops supported a variety of perennial grasses. Enneapogon brachystachyus was the principal pioneer grass species to invade bared rocky ground.

Shrubs were more vigorous and taller grown on the flats than on the ridges. Perennial grasses were ousted from the flats, in pans and among bushes. They found their last refuge under shrubs and in crevices between rocks where they were never grazed as short and where

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they were not as prone to trampling as on the flats. Tragus koelericides in particular was repeatedly observed to be most susceptible to trampling by livestock.

Pans which abounded in Themeda triandra and Sporobolus fimbriatus in 1952 had by 1957 reverted to Eragrostis lehmanniana and Aristida curvata. This was especially true in the case of severely grazed veld and less noticeable as the stocking rate decreased. On lightly grazed veld perennial grasses formed a continuous stand throughout the camps, broken only in the centre of pans. Panicum coloratum was encountered growing in moister depressions in such camps.

E. lehmanniana, Enneapogon brachystachyus, T. koelericides, Chrysopogon montanus, Heteropogon contortus, Enneapogon scoparius, Themeda and Aristida vestita were the first grasses to become active after winter, while Cymbopogon sprouted later but continued sprouting long after sprouts from other grasses had withered away. These sprouts provided valuable forage at a most critical time of the year. The order in which some of the grasses matured were as follows: Enneapogon brachystachyus, Tragus racemosus, Aristida curvata, Eragrostis lehmanniana, Themeda triandra, Cymbopogon plurinodis and Digitaria eriantha.

Both cattle and sheep preferred E. lehmanniana, Themeda, Fingerhuthia and Chrysopogon to Sporobolus and Digitaria. They discriminated against Enneapogon scoparius, Aristida vestita, Cymbopogon and Heteropogon. However, during winter after the grasses stock liked best were cropped short, and also during dry years, all these species were grazed. In general, when matured, perennial, leafy grasses were favoured above stemmy, annual grasses. In early spring with active sprouting these preferences were maintained, but sheep were observed to graze green sprouts from among dried leaves and stems in tufts of Cymbopogon, Heteropogon and Enneapogon scoparius, leaving the mature stems and leaves ungrazed.

Sheep grazed grass leaves first and ignored stems and inflores-

cences.../161

cences until such time when, owing to lack of an alternate food source, they could return to these less favoured parts of plants. Cattle, on the other hand, were much less pronounced in their likes and dislikes, preferring taller growth than sheep. But when cattle were forced to graze all grasses as happened in the case of the severe grazing intensities, steers grazed the veld just as short as sheep were able to crop the grasses. Preferences and discriminations were easiest to discern at the time stock were transferred to their late-summer camps.

Tarchonanthus minor was at all times preferred to T. camphoratus var. litakunensis, Olea africana, R. pyroides, Zizyphus mucronata and others. On dolomitic veld, with less abundant T. minor, stock were observed to make greater use of the other shrubs. Stock, and in particular sheep, commenced browsing even when stems of grasses were still available. In the case of severe grazing this occurred as early as March, but in the case of moderate and light stocking stock usually took to shrubs from June onwards. Sheep were consistently observed to be making more use of shrubs than cattle were making.

With carry-over autumn moisture and consequently prolific sprouting and growth of grasses up to the commencement of summer rains, very little browsing took place in spring, and shrubs were observed to grow shoots of twelve to eighteen inches in length. On severely grazed veld, steers continued to browse for a short while even after the commencement of the first rains, until grass blades grew out long enough to be grazed with ease. Sheep, in turn, left off browsing shrubs sooner after rains set in.

Aristida curvata was eagerly grazed by steers in early-summer and was prevented from seeding by such use. Grazing at other seasons left it practically untouched. Sheep again, favoured Tragus racemosus and Enneapogon brachystachyus immediately after the commencement of the rains.

At the time when stock were transferred from one camp to

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another, severely grazed veld and in dry years even camps under moderate grazing, except for the bush, were left bare and exposed to wind and sun until the next growing season . Also, the animals finished the herbage in camps some time before they were due to be moved and even thick branches and stems of shrubs were browsed. Dead grass tufts and others dying from the centre outwards were common on severely grazed camps, especially on lime.

A whole summer rest enabled all grasses to seed and shrubs to recuperate. Late-summer resting of camps also resulted in grasses running into seed under light grazing but not under either moderate or severe stocking. Geigeria africana was more abundant on both early-summer and whole summer grazed camps than on both late-summer or all summer rested camps.

(3) SOIL ANALYSIS:

In Tables XLIX and L particulars are given of mechanical and chemical analyses of soils obtained from experiments on lime and dolomit veld after being subjected to the different grazing rates for the duration of these experiments.

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TABLE XLIX.

MECHANICAL AND CHEMICAL ANALYSES(s) OF LIMEVELD SOILS UNDER THREE GRAZING RATES WITH CATTLE AND SHEEP AT KOOPMANSFONTEIN.

Soil horizon (inches).	Expt.13 L. 1 Unit/ 9m.			Expt.14 L. 1 Unit/12 m.			Expt.15 L. 1 Unit/15m.		
	0-3	3-6	6-12	0-3	3-6	6-12	0-3	3-6	6-12
pH.	7.45	7.58	7.53	6.78	6.70	6.35	7.62	7.60	7.75
Resistance at 60°F.	1230	1380	950	1360	1450	1470	1220	1080	1210
Mechanical analysis (%):									
Sand(>0.02mm.)	74.02	73.24	72.55	82.56	82.82	77.29	76.89	78.02	70.85
Silt(0.02-0.002 mm.)	13.26	11.76	12.01	7.54	6.22	7.78	10.99	7.53	11.99
Clay(<0.002mm.)	12.72	15.00	15.44	9.90	10.96	14.93	12.12	14.45	17.16
$CaCO_3$.(%)	0.95	2.44	1.57	0.00	0.00	0.00	0.31	0.35	1.92
P.(%)(z)	.0025	.0023	.0018	.0018	.0009	.0005	.0023	.0017	.0019
C.(%)	0.56	0.50	0.48	0.99	0.89	0.81	0.71	0.65	0.54
N.(%)	0.08	0.07	0.06	0.11	0.09	0.08	0.09	0.08	0.07
C : N ratio.	7.3:1	7.7:1	8.0:1	8.8:1	9.6:1	10.1:1	8.3:1	8.4:1	7.6:1
Water-soluble salts(%)(n):									
Na.	.0009	.0005	.0007	.0011	.0010	.0029	.0006	.0007	.0009
K.	.0006	.0003	.0002	.0015	.0010	.0005	.0005	.0003	.0002
Ca.	.0041	.0039	.0033	.0037	.0024	.0022	.0037	.0039	.0042
Mg.	.0011	.0014	.0011	.0007	.0003	.0005	.0020	.0001	.0009
HCO_3.	.0173	.0160	.0167	.0142	.0085	.0118	.0162	.0167	.0182
Cl.	.0024	.0021	.0021	.0030	.0030	.0027	.0024	.0027	.0027

(s) = Analyses by D.F.M. Claassen.

(z) = 1% Citric acid solution.

(n) = Soil : Water :: 1 : 2.

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Depth tendencies of soils from the different grazing intensities are similar. However, the acidity, sand fraction, carbon and nitrogen content and C : N ratio, and sodium, potassium and chlorine contents are highest, while the silt and clay fractions and phosphorus, calcium, magnesium and bicarbonate contents are lowest under the moderate grazing as compared to those under severe and light grazing.

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TABLE L.

MECHANICAL AND CHEMICAL ANALYSES(s) OF DOLOMITEVELD SOILS UNDER THREE GRAZING RATES WITH CATTLE AND SHEEP AT KOOPMANSFONTEIN.

Soil horizon (inches).	Expt.13 D. 1 Unit/ 9m.			Expt.14 D. 1 Unit/12m.			Expt.15 D. 1 Unit/15m.		
	0-3	3-6	6-12	0-3	3-6	6-12	0-3	3-6	6-12
pH.	7.02	6.95	6.60	7.43	7.57	[illegible]	6.50	6.38	6.42
Resistance at 60°F.	1760	1720	1750	1250	1050	[illegible]	1600	1420	1400
Mechanical analysis(%):									
Sand(>0.02mm.)	87.70	86.73	84.20	81.44	81.04	77.21	82.58	79.35	77.70
Silt(0.02-0.002 mm.)	3.05	3.38	2.94	8.28	8.47	13.15	5.08	5.54	4.64
Clay(<0.002mm.)	9.65	9.87	12.86	10.28	10.49	9.64	12.34	15.11	17.66
$CaCO_3$.(%)	0.00	0.00	0.00	0.00	0.21	4.62	0.00	0.00	0.00
P.(%)(z)	.0016	.0011	.0003	.0036	.0038	.0056	.0015	.0005	.0004
C.(%)	0.80	0.84	0.51	0.90	1.02	0.86	0.83	0.74	0.57
N.(%)	0.10	0.09	0.06	0.10	0.10	0.10	0.09	0.08	0.06
C : N ratio.	8.2:1	8.9:1	8.9:1	8.7:1	9.8:1	8.5:1	9.1:1	9.3:1	9.2:1
Water-soluble salts(%)(n)									
Na.	.0013	.0012	.0010	.0010	.0010	.0009	.0012	.0012	.0011
K.	.0010	.0016	.0002	.0008	.0006	.0003	.0011	.0006	.0003
Ca.	.0052	.0044	.0022	.0026	.0026	.0031	.0042	.0048	.0057
Mg.	.0008	.0006	.0007	.0002	.0002	.0004	.0005	.0008	.0013
HCO_3.	.0200	.0173	.0076	.0077	.0090	.0107	.0159	.0164	.0197
Cl.	.0024	.0024	.0024	.0027	.0024	.0024	.0030	.0035	.0024

(s) = Analyses by D.F.M. Claassen.

(z) = 1% Citric acid solution.

(n) = Soil : water :: 1 : 2.

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The depth tendencies of soils from the three grazing intensity experiments show great similarity. Regarding water-soluble salts, soils from the moderate intensity had a lower sodium, potassium, calcium, magnesium and bi-carbonate content when compared to soils from severe and light grazing. The highest sand, silt and clay fractions were obtained respectively from severe, moderate and light grazing. The highest phosphorus, carbon and nitrogen status of soils resulted under moderate grazing.

(4) LIVEWEIGHT:

In Tables LI and LII the summer gain, spring loss, net gain, liveweight maintained per morgen and total digestible nutrients obtained under three grazing intensities with cattle and sheep are given for lime and dolomiteveld respectively.

TABLE L.I../167

GAINS AND LOSSES PER STEER(m) AND PER SHEEP(m), PER MORGEN UNDER THREE GRAZING INTENSITIES ON LIMEVELD AT KOOPMANSFONTEIN.

Seasons.	Total Rainfall (mm.)	Cattle or Sheep.	Summer Gains	Spring Losses	Net Gains	Liveweight maintained per morgen	Net T.D.N. per morgen.
Expt. 13 L - One unit to 9 morgen.							
1952/53.	418	C	198	167	31 (x)	25649	322
		S	36	12	24 (s)	10003	156
1953/54.	378	C	182	174	8 (r)	21699	268
		S	26	7	19 (s)	15165	206
1954/55.	459	C	213	165	48 (n)	22594	293
		S	26	21	5 (s)	16709	204
1955/56.	563	C	229	93	136 (rps)	22711	308
		S	18	11	7 (s)	11356	144
1956/57.	427	C	318	108	210 (s$_2$)	25622	387 (t)
		S	21	16	5 (s$_2$)	6571	89 (t)
Mean per season	449	C	228	141	87	-	-
		S	25	13	12	-	-
Mean per morgen per season.		C	26	16	10	23655	316
		S	11	6	5	11961	160
Expt. 14 L - One unit to 12 morgen.							
1952/53.	418	C	269	137	132 (x)	16744	265
		S	32	15	17 (s)	11499	156
1953/54.	378	C	291	116	175	20268	293
		S	32	8	24 (s$_3$)	8833	132
1954/55.	459	C	227	216	11	18433	230
		S	19	14	5	10342	128
1955/56.	563	C	262	86	176	20835	297
		S	23	6	17 (s)	8882	124
1956/57.	427	C	339	156	183	23168	331 (t)
		S	25	25	0	5525	69 (t)
Mean per season	449	C	278	142	136	-	-
		S	26	13	13	-	-
Mean per morgen per season.		C	23	12	11	20290	283
		S	2	5	4	9016	122
Expt. 15 L - One unit to 15 morgen.							
1952/53.	418	C	312	142	170	20001	277
		S	44	4	40	7176	120
1953/54.	378	C	293	208	85	19364	254
		S	27	5	22	11109	149
1954/55.	459	C	378	177	201	17958	263
		S	15	15	0	10901	118
1955/56.	563	C	329	75	254	17812	269
		S	28	9	19	7105	101
1956/57.	427	C	339	113	226	19572	289 (t)
		S	21	19	2	4361	52
Mean per season	449	C	330	143	187	-	-
		S	27	10	17	-	-
Mean per morgen per season.		C	22	10	12	18941	270
		S	1	3	4	8130	108

C = Cattle.

S = Sheep.

(t) = Season for sheep only eight months long.

(m) = Weights are the mean of four steers and sixteen wethers respectively.

(r) = Ox died from poverty.

(s) = Sheep died from poverty.

(p) = Sheep died from Geigeria-poisoning.

(x) = Stock removed from 3/1/53 - 24/2/53.

(n) = Sheep removed from 4/1/55 - 25/1/55; no herbage left.

s_2, s_3, etc. = Sub-notation denotes the number of animals involved.

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TABLE LII.

GAINS AND LOSSES PER STEER(m) AND PER SHEEP(m) : LIVEWEIGHT MAINTAINED AND T.D.N. OBTAINED IN POUNDS PER MORGEN UNDER THREE GRAZING INTENSITIES ON DOLOMITEVELD AT KOOPMANSPOORTEIN.

Seasons.	Total Rainfall (mm.)	Cattle or Sheep.	Expt.13 D – One unit to 9 morgen. Summer Gains	Spring Losses	Net Gains	Liveweight maintained per morgen	Net T.D.N. per morgen	Expt.14 D – One unit to 12 morgen. Summer Gains	Spring Losses	Net Gains	Liveweight maintained per morgen	Net T.D.N. per morgen	Expt.15 D – One unit to 15 morgen. Summer Gains	Spring Losses	Net Gains	Liveweight maintained per morgen	Net T.D.N. per morgen
1952/53.	418	C	347	168	179	31836	451	332	105	227	23403	343	418	167	251	23801	332
		S	48	2	46	12970	222	45	0	45	9854	166	50	2	48	7883	135
1953/54.	378	C	365	105	260	29484	450	360	120	240	22204	334	424	155	269	21949	322
		S	26	6	20	18069	240	25	6	19	14036	185	30	7	23	11035	125
1954/55.	459	C	239	189	50	27902	357	245	219	26	22387	280	264	145	119	18615	247
		S	30	5	25	11844	177	32	11	21	8638	127	25	12	13	6521	89
1955/56.	563	C	343	108	235	29159	437	354	56	296	21048	333	316	71	245	20610	298
		S	31	5	26	12491	186	31	8	23	9733	144	32	7	25	7689	113
1956/57.	427	C	320	123	197	31776	454	294	122	172	23440	331	304	132	172	20609	284
		S	18	23	-5	7865	90	18	17	1	6123	76	19	21	-2	4719	53
Mean per season.	449	C	323	139	184	–	–	317	124	193	–	–	345	134	211	–	–
		S	31	8	23	–	–	30	8	22	–	–	31	10	21	–	–
Mean per morgen per season.		C	36	15	21	30031	430	26	10	16	22 96	324	23	9	14	21117	296
		S	14	4	10	12640	183	10	3	7	9677	139	8	2	6	7569	103

(m) = Weights are the means of four steers and sixteen sheep respectively.

(t) = Season for sheep only eight months long.

C = Cattle.

S = Sheep.

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Little difference existed between the spring liveweight loss of steers on the different grazing intensities on limeveld. The lowest spring liveweight loss in sheep occurred under light grazing. Summer and net gains of cattle were proportional to the intensity of grazing in so far that the highest gains were obtained from the lighter stocking and the poorest gains from severe grazing.

Summer gains and spring losses of both steers and sheep on a per morgen basis, decreased with less severe grazing. Net gains of steers decreased with heavier stocking rates while those of sheep increased under such conditions. The best liveweight maintenance and highest total digestible nutrients were obtained from severe grazing.

On a per steer basis, the different grazing rates on dolomite-veld made little difference to summer gains and spring losses. Net gains however, declined under heavy grazing. Summer gains and spring losses of sheep were similar under the different stocking rates but net gains decreased with an increase in area per sheep.

On a per morgen basis, the highest summer and net gains and also spring losses of steers were recorded from severe grazing. The reverse occurred under light stocking rates. Summer gains, spring loss in liveweight, net gains, liveweight maintenance and total digestible nutrients obtained of both sheep and cattle declined with lighter grazing.

No tendency was evident on either lime or dolomite for liveweight gains, losses, maintenance or total digestible nutrients either to increase or decrease over the five years the experiments were in progress.

(5) AREA OF THE LIVEWEIGHT-CURVE:

In Tables LIII and LIV the area below the liveweight-curve of paired groups of sheep and paired steers are given for stock grazing lime and dolomiteveld respectively at the three stocking rates.

TABLE LIII.../170

TABLE LIII.

AREA BELOW THE LIVEWEIGHT-CURVE OF CATTLE AND SHEEP GRAZING LIVEVELD UNDER THREE GRAZING INTENSITIES.

STEERS

Period on Experiment.	Experiment 13 L: One unit to 9m. Steer No.	Area.	Experiment 14 L: One unit to 12m. Steer No.	Area.	Experiment 15 L: One unit to 15m. Steer No.	Area	Calculated values of H*	Significant Differences P ≤ 0.010.
							13L/14L; 14L/15L; 13L/15L	13L/14L; 14L/15L; 13L/15L	
2.7.52 - 15.7.53.	77	10712	E.32	12438	E.24	12277	13.01	3.15; 0.64; 2.98	<0.001; 0.261; <0.001	15L;14L >13L.
2.7.52 - 13.7.54.	E.55	16967 (r)	E.30	17425	E.52	21790	18.09	0.32; 3.61; 4.12	0.375; <0.001; <0.001	15L - 14L;13L.
2.7.52 - 13.7.54.	106	-	E.33	16593	E.54	22087	-	-; 5.35; -	-; <0.001; -	15L >14L.
2.7.52 - 12.7.55.	E.56	21363	763	25613	E.53	37012 (r)	60.94	2.10; 6.55; 5.19	0.018; <0.001; <0.001	15L >14L;13L.
16.7.53 - 10.7.56.	270	16990	266	21282 (r)	265	-	-	4.19; -; -	<0.001; -; -	14L >13L.
14.7.54 - 10.7.56.	415	17347 (r)	428	-	413	19557	-	-; -; 1.79	-; -; 0.037	N.S.
14.7.54 - 6.7.57.	127	-	411	30072	409	31562	-	-; 1.08; -	-; 0.140; -	N.S.
13.7.55 - 6.7.57.	511	13793	519	17086	518	20371	6.86	-; -; -	-; -; -	N.S.
11.7.56 - 6.7.57.	639	7973	650	7417	681	7520	3.38	-; -; -	-; -; -	N.S.

SHEEP(a)

1.7.52 - 12.7.55.	3412	3334	3774	12.77	1.37; 3.30; 2.55	0.085; <0.001; 0.005	15L >14L;13L.
13.7.55 - 6.7.57.	1229	1305	1306	3.87	-; -; -	-; -; -	N.S.

(a) = The area of the liveweight-curve was calculated from the average liveweight of 16 sheep in each experiment.

* = H-requirement = 9.21 at P = 0.010 (2 D.F.)

(r) = The weight recordings of these steers does not fit the requirements of area calculation according to Simpson's rule of equidistance.

N.S. = Not significant.

TABLE LIV.../171

TABLE LIV.

AREA BELOW THE LIVEWEIGHT-CURVE OF CATTLE AND SHEEP GRAZING DOLOMITEVELD UNDER THREE GRAZING INTENSITIES.

STEERS.

Period on Experiment.	Experiment 13 D: One unit to 9 m: Steer No.	Area.	Experiment 14 D: One unit to 12m: Steer No.	Area.	Experiment 15 D: One unit to 15m: Steer No.	Area.
2.7.52 - 15.7.53.	204	16982	290	16207	193	18985
2.7.52 - 13.7.54.	E.62	17695	E.51	18828 (r)	E.58	23927
2.7.52 - 13.7.54.	E.61	18618	E.50	-	E.49	26330
2.7.52 - 12.7.55.	E.63	27250	E.48	29752	E.59	31107
16.7.53 - 10.7.56.	237	24452	206	23465	262	30033
14.7.54 - 6.7.57.	401	31605	403	28777 (r)	416	33663
14.7.54 - 6.7.57.	405	30715	507	-	402	32383
13.7.55 - 6.7.57.	510	12640	517	17927	506	16053
11.7.56 - 6.7.57.	629	6620	630	7385	616	6598

Calculated values of H*	z: 13D/14D	z: 14D/15D	z: 13D/15D	P: 13D/14D	P: 14D/15D	P: 13D/15D	Significant Differences P ≤ 0.010.
18.20	1.75	3.85	2.97	0.040	<0.001	<0.002	15D>14D;13D.
19.78	0.78	3.35	4.41	0.176	<0.001	<0.001	15D>14D;13D.
-	-	-	4.86	-	-	<0.001	15 D>13 D.
8.51	-	-	-	-	-	-	N.S.
15.96	1.28	3.57	2.66	0.100	<0.001	<0.004	15D>14D;13D.
8.12	-	-	-	-	-	-	N.S.
-	-	-	1.12	-	-	0.131	N.S.
11.22	3.90	2.15	3.29	<0.001	0.016	<0.001	15D;14D>13D.
0.54	-	-	-	-	-	-	N.S.

SHEEP (s)

1.7.52 - 13.7.54.	2509	2688	2551	2.61	-	-	-	N.S.
14.7.54 - 12.7.55.	950	912	867	3.51	-	-	-	N.S.
13.7.55 - 6.7.57.	1387	1436	1418	0.878	-	-	-	N.S.

N.S. = Not significant.

(s) = Area of the liveweight-curve was calculated from the average liveweight of 16 sheep in each experiment.

* = H-requirement = 9.21 at P = 0.010 (2 D.F.)

(r) = According to Simpson's rule of equidistant weight recordings, area calculation of the liveweight-curve was not justified in those cases.

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In those instances where the liveweight-curve of steers differed significantly, light grazing resulted in the larger area in nine and moderate stocking in one determination. Of the remaining eight comparisons in which significance between areas was not established, light grazing proved superior in six and moderate and se[illegible]ing in one comparison each.

[illegible]iveweight-curve area determinations in the case of [illegible]cking resulted in the larger area in two cases, one of which was significant, moderate grazing in another two and severe grazing in one case only.

(6) SLAUGHTERINGS:

In Table LV slaughter particulars, capital investment, net profit and rate of interest, applicable to steers only, are given for the three grazing intensities on lime and dolomiteveld respectively. Details of slaughterings of sheep were not available.

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TABLE LV.

SLAUGHTER DETAILS AND FINANCIAL RETURNS OF STEERS(m) UNDER THREE GRAZING RATES WITH CATTLE AND SHEEP AT KOOPMANSFONTEIN.

	Limeveld.			Dolomiteveld.		
	Expt.13L: One unit: to 9 m.	Expt.14L: One unit: to 12 m.	Expt.15L: One unit: to 15 m.	Expt.13D: One unit: to 9 m.	Expt.14D: One unit: to 12 m.	Expt.15D: One unit: to 15 m.
Liveweight in pounds.	769	903	1012	1018	1001	1142
Warm carcase-weight in pounds.	368	449	529	512	520	606
Dressing percentage.	48	49	52	50	52	53
Grade.	II	II	Prime	I	I	Prime
Wet hide-weight in pounds.	51	55	68	71	65	78
Capital investment.						
Land @ R12 per morgen.	R432	576	720	432	576	720
Steers @ R.24 each.	R216	216	216	216	216	216
Replacement steers @ R24 each.	R 72(t)					
Licks and inoculations.	R 40	40	40	40	40	40
Total capital investment.	R760	832	976	688	832	976
Gross return from 9 steers over 5 years.	R307.5	375.9	535	476.4	466	575.7
Less stock expenditure.	R328	256	256	256	256	256
Excess of grass return over expenditure.	-R 20.5	119.9	279	220.4	210	319.7
Profit per morgen per year.	-11c	50c	93c	122c	88c	107c
Interest rate per annum (%).	-0.6	2.9	5.7	6.3	5.1	6.6

(m) = Slaughter details are the mean of nine steers for every experiment.

(t) = Three steers died as a result of poverty and had to be replaced.

Steers from lightly grazed veld dressed and graded better and yielded heavier carcasses and hides than steers from either moderately or severely grazed veld. Also, these last mentioned steers graded poorer on lime than on dolomite.

On a per morgen basis on limeveld, severe grazing, because of deaths due to poverty, resulted in a loss of eleven cents; the return per morgen and rate of interest on moderate grazing was only about half-as-much as on light grazing. On the same basis, severe grazing on dolomiteveld was responsible for the highest return per morgen and second only to light grazing in the rate of interest on invested capital. Moderate grazing yielded the least both in respect of return per morgen and rate of interest.

(7) GEIGERIA-POISONING AND OTHER DEATHS:

During the course of five years no losses occurred on dolomiteveld, nor did any take place on lightly grazed limeveld. Three steers and three sheep were lost to poverty and one sheep to "vermoersiekte" on severely grazed limeveld. Five sheep were lost to poverty on moderate grazing.

DISCUSSION:

The increase in seral, weed, karroid and herbaceous species, particularly E. lehmanniana, Oropetium, Aster and Monechma, and a decrease in climax species suggests a rearranging of the constituent species towards a biotic sub-climax under joint grazing by cattle and sheep. It is anticipated that this condition of veld will be reasonably stable within the vagaries of the rainfall. The importance of moisture to vegetation survival was strikingly shown by Whitman, Hanson and Petersen (1943) who found grass density in North Dakota to be reduced by one-third between droughts. Lang (1945) also found a striking relationship between the precipitation during any twelve-month period and the density of the vegetation in the subsequent growing season.

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The absence of evidence that yields declined with the reversion of veld to the biotic sub-climax gives every reason to expect production from such veld to be maintained.

The appearance of Chrysocoma on severely grazed limeveld and its stability under other stocking rates and also on dolomite is attributable to the yearlong grazing intensity of one beast and four sheep being too severe for limeveld. The ground was left unoccupied by the receding grasses, a condition eminently suitable for invasion by other plants. The most likely reason why Chrysocoma failed to increase on dolomite is that on this veld type, rocks and ridges were very common. Trampling and overgrazing of the veld to the same extent as on lime was not possible. In addition, because of its impervious nature in comparison with limestone, rain falling on dolomite rock flows down onto the soil while on limestone water is absorbed by the rock. This rendered moisture relations more favourable on dolomite. This enabled grasses to be more tolerant to severe defoliation on dolomite and the veld less liable to Chrysocoma-encroachment.

Acocks (1953) confirms the tendency for Karoo invasion to commence and to be more severe on flats than on hills, mountains and rocky sites. Shaw (1875), in commenting on the invasion of grass areas by Karoo bushes, views the encroachment of Chrysocoma as a definite index of either a changing climate or of deteriorating moisture conditions. It is singularly unfortunate that no credence can be placed on the frequency counts of Geigeria from the surveys of two seasons only. The behaviour of this species under the different stocking rates and the position it occupies in the biotic sub-climax would have been illuminating to follow. The dire need for annual counts over a long period of time to obviate conclusions being drawn from seasonal variation is evident.

It is fortunate that in spite of the preference stock exhibited for E. lehmanniana, this seral grass nevertheless increased in the biotic sub-climax. The preference of stock for some herbage plants

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above others is difficult to explain. Cowlishaw and Alder (1960) suggest that the grazing habits of a ruminant animal are affected by the animal's physiological state, its previous history, the herbage environment and the palatability of available herbage. Milford, Hutton and Miles (1958) mention nutritive value also as affecting the grazing habits of livestock.

There is every reason to regard shrubs as a valuable source of herbage at all times. This was illustrated by the fact that, under light grazing, stock rarely had to subsist on shrubs alone; under moderate grazing these plants supplied animals with browse in periods of grazing shortage; while under severe grazing, in an effort to survive, stock were obliged to browse shrubs in all seasons. The avoidance of shrubs by stock in abundant rainfall seasons makes these woody plants an excellent fodder reserve for use in poor years.

The observation that sheep were pre-eminently grazers of grass leaves while cattle took stems along with leaves conformed to the results obtained by Cook, Cook and Harris (1948) in Northern Utah. These authors found sheep to prefer grazing leaves rather than stems on all types of grazing and in all seasons. They also found stems, although twice as abundant as leaves, to comprise only 44 per cent of the diet of sheep.

The high preference stock exhibited in favour of Tarchonanthus minor, suggests that this woody shrub should be used as a measure of grazing pressure. When continually browsed down it will become stunted and die out, so that only shrubs of much lower acceptance value would be left to stock. Acocks (1953) described this condition as follows:"The Karoo invasion is proceeding rapidly while valuable fodder shrubs like Tarchonanthus minor are suffering the usual fate of useful plants, being killed out."

With regard to botanical changes on these veld types, a whole range of grazing intensities appears to be practicable. Of these, severe stocking led to the highest total digestible nutrients obtainable and the best gains per morgen. It was also the cause of stock

losses.../177

losses during poor years and of beef inferior in quality. On the other hand, light grazing resulted in a lowering of both total digestible nutrients obtained and of gain per morgen, but beef of the best quality resulted, and finally the best rates of interest on invested capital were obtained.

Cattle liveweight gains from the different grazing intensities on dolomiteveld conformed to the now familiar pattern of highest net gains per head from light grazing but among the lowest net gains per head from severe grazing. With conversion of gains to a per morgen basis the reverse applies. Contrary to this, on lime, no matter whether gain per head or gain per unit area was taken as the basis for comparison, the best net gains originated from light grazing and severe stocking resulted in the poorest gains. This unconformity of gains on limeveld is because both moderately and severely stocked limeveld were in fact overgrazed to an appreciable degree. A lower number of steers would have been more in harmony with the production of herbage on the veld, which would have been in better condition as a consequence. From this it appears as if the inherent ability of animals to put on weight had not been exhausted in any of the experiments. An increase in the area per steer would no doubt have resulted in greater liveweight gains per animal.

The absence of a tendency for either liveweight maintenance or for gains to decline suggests sustained production from the veld. The lower net gains and total digestible nutrients obtained per morgen during the ultimate season is ascribable to the termination of sheep grazing after only eight months instead of the usual twelve. Poor net gains for the 1954/55 season were due to wethers being already full-grown at the closure of the previous season; as a consequence of which they gained less weight in summer and lost more in spring than younger sheep would have done.

The constancy with which stock made use of herbage obtained under the different stocking rates is striking. Irrespective of the intensity of grazing, just over three-fourths of the nutrients

derived.../178

derived form the veld were diverted to maintenance and a little less than one-fourth were used for liveweight gain. Different stocking rates, however, differed widely in the amount of total digestible nutrients lost in spring. On the whole, both cattle and sheep lost less total digestible nutrients in spring on dolomite in comparison with what they lost on limeveld in the same season.

The amount of total digestible nutrients obtained by sheep against that obtained by cattle conformed approximately to a ratio of 1 : 2 in these experiments where sheep and cattle jointly grazed veld at a ratio of one steer to four sheep. A tendency existed for cattle to obtain proportionately less and for sheep to derive proportionately more total digestible nutrients under severe grazing. This indicated an ability on the part of sheep to go on producing under adverse grazing conditions or showed that sheep were better able than cattle to tolerate severe grazing.

Unfortunately, wethers were not slaughtered and graded in the same way as steers, and financial particulars are therefore not available. Considering revenue from steers only, the per morgen returns and rate of interest on capital suggested that higher liveweight maintenance and total digestible nutrients obtained per morgen from severe grazing did not lead to increased dividends; instead, a loss was incurred on limeveld under such a stocking rate. Death losses accounted for some of this liability, but even when direct losses were ignored from the calculations, severe grazing still did not reach the level of returns realized under light grazing. Maclagan (1939), in commenting on overgrazing on American and Australian rangelands, confirms this effect of overstocking when he affirms that, "in the low rainfall areas the question is clearly one of overstocking by domestic livestock, either of cattle and sheep separately or in competition with each other."

On dolomiteveld, slaughter results were not proportional to the grazing intensity. In fact, the highest rate of interest resulted from light grazing while the best return per morgen accrued from the

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heaviest grazing. This anomaly is most probably due to the ability of dolomiteveld to withstand heavier grazing better than lime. (The same tendency was evident in the case of different stocking rates with sheep reported in an earlier chapter.) It is also probable that under moderate and light grazing the ceiling ability of steers to gain was reached on a smaller area than that prescribed. The additional veld served only to suppress the per unit area returns.

The occurrence of sheep deaths on severely and moderately grazed limeveld indicated that poverty losses must be expected from this veld sub-type under any but the lightest use. In cases where moderate and severe stocking are practised recourse to supplementation in an effort to avoid deaths, will be essential. The main conclusion to be drawn from these experiments is that the effects of varying the grazing intensities on the veld were not sufficiently marked over five years either to justify the rejection or approval of any of them. On limeveld, a light stocking rate paid the best dividends. Dolomite was found to be superior to limeveld as regards financial returns. In addition, dolomite withstood heavier stocking longer and better without it adversely affecting the revenue per unit area.

ANNEXURE 10.../180

Author Ebersohn J P
Name of thesis Ecology of Xerophytic Savannah of Griqualand west with special reference to grazing 1962

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