Interrelationships Between Fire, Grazing and Grass Cover at the Bontebok National Park

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Point surveys of permanently marked plots were conducted with the aim of (i) determining the change in grass height, cover and degree of defoliation with increasing time after veld burning and (ii) determining which plant species are most intensively defoliated by herbivores (mainly bontebok and grey rhebok). Grass was the most heavily defoliated component of the vegetation, whereas Restionaceae and Cyperaceae were generally avoided. No grass species was consistently avoided by herbivores, and no species was consistently favoured. Instead selection among species varied with growth stage. The tall, coarse species were favoured on new burns when the vegetation was still short. The short species came into favour once the sward had grown taller. Defoliation was heaviest within the first year after burning and thereafter decreased substantially. The introduction of coarse grass grazers such as mountain zebra to the park might lead to greater use of the mature veld. Those grass species that underwent the heaviest defoliation on new burns (over 50% of leaves severed) showed three- to seven-fold increases in canopy spread cover over subsequent years. Thus heavy use of recently burnt veld is not necessarily deleterious.

Key words: Defoliation, food preferences, canopy cover, renosterveld, point surveys, ungulates, bontebok, grey rhebok, mountain zebra, rotational burning.

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Introduction

The Bontebok National Park (BNP) has as its primary conservation objective "the maintenance of a viable and genetically pure bontebok *Damaliscus dorcas dorcas* population" (Robinson, Van der Walt, De Graaff & Pieterse 1981). The conservation objectives for the vegetation of the park are two-fold: firstly to maintain plant communities capable of meeting the food requirements of the large herbivores, and secondly to preserve the diversity of plant species that occurs in the region. The increasing rate of disappearance of the natural vegetation from the areas surrounding the park to make way for wheat production has highlighted the importance of the second objective.

In order to promote a more even distribution of grazing pressure, a rotational burning programme was introduced in 1975. The park was divided into blocks or burning units, varying in size from 6 ha to 356 hectares. A proportion of these units, those with a reasonable cover of grass, are burnt in rotation at four-year intervals. These blocks, comprising 49% of the area of the park, are managed primarily to meet the food requirements of the large herbivores. The remaining blocks, those with less grass and a greater variety of characteristic fynbos plants, are burnt in rotation at longer intervals (10 – 12 years) to promote the survival of the seed regenerating Proteaceae (Bond, Vlok & Viviers 1984). In these areas the maintenance of plant species diversity receives priority over herbivore requirements.

This study concerns the first group of blocks, those burnt at four-year intervals. Although the requirements of the ungulate populations receive priority in these parts of the park, it is considered necessary to reconcile this aim as far as possible with the maintenance of plant species diversity. The frequency of burning is of critical importance to the attainment of both these objectives. The time interval between fires has been shown to play an overriding role in determining species composition and species diversity of fynbos plant communities (Martin 1966; Bond *et al.* 1984). The tendency of most wild ungulates to congregate on burnt areas is also well known (Pienaar 1968), and this is clearly evident in the bontebok *Damaliscus dorcas dorcas* (Pallas, 1766), and grey rhebok *Pelea capreolus* (Forster, 1790) populations in the BNP (Beukes 1984). This means that grazing pressure is concentrated on the newly burnt veld, and the more mature vegetation is little used. In consequence managers are heavily dependent on fire to rotate the grazing pressure.

This situation is probably aggravated by the fact that the bontebok, the only specialised grazing ungulate in the park, prefers short grass (Beukes 1984). Mature grass is almost totally avoided. African grasslands evolved in association with a wide variety of grazing ungulates, and it has been shown that different ungulate species favour grasses of different heights (Bell 1970; Grobler 1983). Both the plains and mountain zebras *Equus burchellii* (Gray, 1824) and *Equus zebra* Linnaeus, 1758 as well as the red hartebeest *Alcelaphus buselaphus* (Pallas, 1766) favour relatively long grass, generally feeding more than 40 mm to 50 mm from the ground. In contrast the blesbok *Damaliscus dorcas phillipsi* Harper, 1939, a close relative of the bontebok, grazes mostly below 50 mm from the ground (Grobler 1983). These different requirements mean that the different grazers can complement one another, the zebra being the first to move into areas of longer grass, and by grazing and trampling they open up the sward for those species that favour shorter grass (Bell 1970).

Thus there is reason to believe that the introduction of Cape mountain zebra and/or hartebeest into the park (both species occurred in the region in historical times (Skead 1980)) would result in greater use of the older veld and a more even distribution of grazing pressure. This might reduce the current dependence of management on fire to rotate the grazing pressure, and permit the option of extending the interval between fires should it prove necessary in the interest of maintaining plant species diversity.

The objectives of the study were:
(i) to determine which components of the vegetation undergo the heaviest defoliation, so as to identify those species that may be vulnerable to overuse;
(ii) to determine the extent to which grass cover, grass height, and grazing pressure change with increasing time after burning; and
(iii) to assess the desirability of introducing long grass grazers into the park.

The emphasis of the study was on the grasses, as these are the main food resource of the bontebok and their utilisation has not been studied before. The degree of defoliation of the grasses at the BNP was also compared with that at the Mountain Zebra National Park and Addo Elephant National Park, where grazing pressure was assessed using similar methods.

Study area and study animals

The BNP, situated seven kilometres south of Swellendam in the southern Cape Province, covers an area of 2 786 hectares. The vegetation of the general region is classified as South Coast Renosterveld (Moll & Bossi 1983). The rainfall is non-seasonal, the annual mean being 515 mm in the BNP for the period 1961 to 1983.

During the study period (1983 – 1985) the bontebok population varied between 240 and 280, and the grey rhebok varied between 175 and 200 individuals. The other ungulates present in the park included small numbers of springbok *Antidorcas marsupialis* (Zimmerman, 1780), grey duiker *Sylvicapra grimmia* (Linnaeus, 1758), grysbok *Raphicerus melanotis* (Thunberg, 1811) and steenbok *Raphicerus campestris* (Thunberg, 1811).

The bontebok is, as noted, almost exclusively a grazer. Beukes (1984) found that only 2,5% of the diet comprises plants other than grass. Conversely, the grey rhebok is a browser and on average grasses comprised only 2,7% of their diet (Beukes 1984).

The substrates of the park are largely gravel terraces and alluvium (Theron 1967). This study was conducted on the alluvium in the western part of the park, an area where the soil is a sandy loam tending towards clay in parts (Grobler & Marais 1967). In contrast to most of the surrounding areas surface gravel is virtually absent.

This area was subjected to intensive use by man before the park was proclaimed. Between 1848 and 1904 it was used as a race course for horses, and between 1952 and 1960 part of it was used as a shooting range. As part of the town commonage of Swellendam it was grazed by domestic livestock (before 1960).

The study sites were situated in the renosterbos communities of the flats and ridges (Grobler & Marais 1967).

Methods

In June 1984 eight vegetation survey plots were laid out, four on burning units that had been burnt in March 1983 and four on units that had been burnt in March 1984. The main aim of the study was to determine the effect of grazing on the vegetation, so it was considered desirable to locate the plots on habitat patches favoured by bontebok. As an aid to achieving this the following method of locating the survey plots was used. Groups of grazing bontebok were located adjacent to the roads that form the boundaries between the burning blocks. Each time a group was sighted a peg was driven into the ground as near as could be judged to the position at which the animals were grazing. The peg marked the location of the monitoring plot. The procedure was repeated until the required number of plots had been located.

The numbers of plots surveyed were insufficient to represent conditions prevailing over all the burnt units. The intention was rather to examine relationships between vegetation cover, height and degree of defoliation in examples of habitat used by bontebok.

Point surveys were conducted in each plot using the method of Roux (1963) as modified by Vorster (1982). The points were arranged in parallel rows of 25, with 1 m spacing between points. Rows were spaced 3 m apart. From six to 10 rows were sampled at each plot, giving 150 to 250 points.

If a point fell within the perimeter of the canopy of a plant it was recorded as a canopy spread strike (Roux 1963), otherwise it was recorded as a "miss". For each strike the following information was recorded:

(i) The plant form: either (a) Gramineae (b) Restionaceae (c) Cyperaceae and (d) all other plants.
(ii) Plant species.
(iii) Plant height (from ground level to the tallest leaf).
(iv) The degree of defoliation by herbivores. This was subjectively assessed by estimating the percentage utilisation of the shoot ends of the shrubs and forbs, and the leaves in the case of the grasses. Each plant was scored according to the following scale:
0 : no visible defoliation
1 : 1 to 5% of shoots severed
2 : 6 to 25% of shoots severed
3 : 26 to 50% of shoots severed
4 : 51 to 75% of shoots severed
5 : 76 to 100% of shoots severed.

The scores were awarded purely on the basis of severed leaf or shoot ends. No attempt was made to estimate the actual quantity of material that had been removed from the plant. In analysing the data the percentage of severed leaves/shoots of each plant was assumed to be equal to the mid-point of the class to which it was assigned. From the mid-point values a mean percentage defoliation was calculated for each of the more common species. This mean is referred to as the defoliation index.

The plots were first surveyed in October 1984, and then again 13 months later in November 1985. As the plots were marked with stakes the second survey was conducted at the same locations as the first.

The surveys did not yield sufficient numbers of the less common grass species to derive a reliable indication of defoliation. Sample sizes of grass tufts inspected for grazing were therefore increased by conducting additional step point surveys (Mentis 1981) in each plot. The tuft of the required species rooted nearest to each step point was assigned to one of the defoliation classes. The step point surveys were continued until at least 10 tufts of the required species had been examined. In November 1985 step point surveys for defoliation were conducted at two additional sites on a block burnt in April 1985. These were done in order to assess the degree of defoliation of the grass species on the most recent burn.

The grass species *Pentaschistis airoides* (Nees) Stapf, *P. densifolia* (Nees) Stapf, *P. thunbergii* (Kunth) Stapf and *P. patula* (Nees) Stapf proved difficult to distinguish from one another in the field and this group was simply recorded as *Pentaschistis* spp. The much larger *Pentaschistis eriostoma* (Nees) Stapf was easily distinguishable from the other members of the genus in the study area.

Data analysis

Values for canopy spread cover, mean per cent defoliation, and mean grass height were calculated for each plot. Using the values for each plot as the units of observation the data were subjected to analysis of variance. In determining the significance of differences between the 1983 and 1984 burns the analysis of variance was conducted as for a fully randomised design. As noted the 1985 survey was conducted on the same plots as the 1984 survey. The differences between the two surveys were therefore analysed according to a randomised blocks design with monitoring plots regarded as 'blocks' and the two years as 'treatments' (Little & Hills 1978).

The data did not conform to the requirements for the analysis (normal distribution and homogeneity of variance), and so transformations were necessary. The log transformation was applied to the grass height values, and the angular transformation to the per cent defoliation and canopy spread cover values.

Relationships between the heights and degree of defoliation of the different grass species were analysed by means of a simple regression analysis.

Results

Before discussing the effects of defoliation the most conspicuous changes in vegetation cover and height during the study period are described.

In all plots total plant *canopy spread cover* showed a pronounced increase from 1984 to 1985 (Table 1). The difference, tested for the combined data from the

Table 1
Per cent canopy spread cover of vegetation in monitoring plots at the Bontebok National Park

Time of fire	Plot no.	Time of survey	
		October 1984	November 1985
March 1983	2	44%	69%
	6	57%	89%
	8	35%	66%
	9	51%	89%
Means for 1983 burn		47%	78%
March 1984	4	31%	74%
	5	30%	63%
	7	32%	61%
	10	46%	77%
Means for 1984 burn		35%	69%

Table 2

Per cent canopy spread cover of grasses and other plant forms in monitoring plots at the Bontebok National Park: changes in cover from 1984 to 1985 compared between two burns. The values in each column are based on the pooled results of four plots

Time of survey	Oct. 1984	Nov. 1985	Oct. 1984	Nov. 1985
Time of fire	March 1983	March 1983	March 1984	March 1984
GRASS SPECIES				
Themeda triandra	11,2	28,3	6,5	17,1
Eragrostis curvula	0,3	2,1	1,4	6,4
Pentaschistis eriostoma	2,0	8,3	0,2	1,4
Merxmuellera stricta	0	0,3	0,2	1,1
Ehrharta capensis	1,7	1,2	2,2	0,7
Cynodon dactylon	0,8	2,6	0,6	1,0
Stipagrostis zeyheri	0	0	1,1	4,0
Ehrharta calycina	0	0	0,5	0,4
Pentaschistis spp.[a]	0,9	0,6	0,4	1,6
Plagiochloa uniolae	2,0	1,1	0,5	3,1
Digitaria eriantha	0	0,2	0,4	2,1
Lasiochloa spp.	0,3	0,3	0,4	0,1
Microchloa caffra	0	0	0	0,1
Sporobolus africanus	0,9	1,1	0	0
Festuca scabra	0	0,3	0	0
Eragrostis capensis	0,9	0,8	0	0
Brachiaria serrata	0	0,5	0	0
Triraphis andropogonoides	0	0,2	0	0
Cymbopogon plurinodis	0,2	0	0	0
Briza maxima	0	0	0,2	0
Aristida junciformis	0,5	0,5	0	0,1
Heteropogon contortus	0	0	0	0,1
Unidentified grasses	0,2	0	0,9	0
PLANT FORM CATEGORIES				
Grasses, all species	21,0	48,4	15,5	39,3
Cyperaceae	4,3	3,4	6,4	8,7
Restionaceae	6,3	9,1	3,4	11,7
Other plants	19,4	39,4	10,4	29,9
Sample sizes: numbers of points	650	650	850	700

[a]*Pentaschistis* spp. includes *P. airoides, P. densifolia, P. thunbergii* and *P. patula.*

1983 and 1984 burns, was highly significant (F = 216,32; df 1 and 7; $P < 0,01$). Table 2 shows that the canopy spread cover of all plant forms except Cyperaceae increased markedly from 1984 to 1985. An increase in cover would be expected as the post-fire regrowth progressed, but growth was probably accelerated by the above average rain which fell during 1985. The rainfall over the 12 months preceding the 1984 survey was 409 mm, which was significantly less than the annual 515 millimetres. In contrast 611 mm fell during the 12 months preceding the 1985 survey.

Table 3

Heights of the tallest leaves of grasses (in mm) in monitoring plots in the Bontebok National Park. The values are means of all grasses in each plot

Time of fire	Plot no.	Time of survey	
		October 1984	November 1985
March 1983	2	47	106
	6	41	100
	8	69	243
	9	35	115
Means for 1983 burn		48	141
March 1984	4	48	205
	5	32	76
	7	27	82
	10	48	191
Means for 1984 burn		39	139

The abundant rain of 1985 also promoted a roughly three-fold increase in the mean *height of the grass* from 1984 to 1985 (Table 3). For the pooled data from the 1983 and 1984 burns the difference between years in grass height is highly significant (F = 171,6; df 1 and 7; $P < 0{,}01$).

Neither canopy spread cover nor mean grass height differed significantly between the 1983 and 1984 burns (Tables 1 and 3). However, the numbers of plots on each of the two burns were small, a larger sample size would have been required to reliably determine the differences between them.

The degree of defoliation of the different plant forms

Grass

The degree of defoliation of grasses was highest within the first year after fire, and declined with increasing time after burning (Table 4). For the combined data from the 1983 and 1984 burns there was a highly significant decrease in the defoliation index from 1984 to 1985 (F = 42,80; df 1 and 7; $P < 0{,}01$). Within each survey period defoliation of grass tended to be highest on the most recent burn. Thus for the 1984 survey the defoliation index on the plots burnt in 1984 (surveyed 7 months after burning) was significantly higher than on the plots burnt in 1983 (19 months after burning) (F = 11,47; df 1 and 6; $P < 0{,}05$). In 1985 the defoliation index was again higher on the 1984 than the 1983 burn but the difference was not statistically significant.

Other plants

Like that of the grasses the defoliation index of the "other plants" tended to decline with increasing time after burning (Table 5). The combined mean for the two

Table 4
Indices of defoliation of grasses (all species) in monitoring plots in the Bontebok National Park. The values in parentheses are numbers of grass tufts inspected for signs of utilisation

		Time of survey	
Time of fire	Plot no.	October 1984	November 1985
March 1983	2	5,0	0,4
		(23)	(35)
	6	25,9	1,0
		(46)	(106)
	8	3,4	0
		(23)	(57)
	9	22,8	0,1
		(50)	(116)
Means for 1983 burn		14,3	0,4
March 1984	4	36,0	0
		(40)	(104)
	5	35,9	7,3
		(26)	(48)
	7	61,1	10,0
		(9)	(10)
	10	44,2	0,8
		(56)	(115)
Means for 1984 burn		44,3	4,5

burns was significantly higher in 1984 than in 1985 (F = 10,46; df 1 and 7; $P < 0{,}05$). The defoliation index did not, however, differ significantly between the two burns, either in the 1984 survey or in that of 1985 (Table 5).

Cyperaceae and Restionaceae

Cyperaceae were lightly grazed (a mean of 4% of leaves bitten off) during the first year after burning (i.e. on the 1984 burn surveyed in 1984), but no signs of use of Cyperaceae were recorded during any of the other surveys. No evidence of feeding on the Restionaceae was detected in any of the surveys. The light defoliation of plants belonging to these families is in accord with Beukes (1984) who found only traces of Restionaceae and Cyperaceae in the rumens of bontebok and grey rhebok.

Defoliation of grass compared between parks

Table 6 compares the grazing pressure at the BNP with that at the Addo Elephant and Mountain Zebra National Parks. Comparisons are made of the degree of defoliation of *Themeda triandra*, one species that is common in all three parks,

Table 5

Indices of defoliation of "other plants" (all plants other than grasses, Restionaceae and Cyperaceae) in monitoring plots in the Bontebok National Park. The values in parentheses are numbers of plants inspected for signs of utilisation

Time of fire	Plot no.	Time of survey	
		October 1984	November 1985
March 1983	2	0,7 (25)	1,8 (53)
	6	2,0 (49)	0,2 (77)
	8	2,7 (22)	0 (76)
	9	1,5 (28)	0,6 (48)
Means for 1983 burn		1,7	0,7
March 1984	4	15,4 (17)	1,1 (33)
	5	3,8 (25)	0,7 (52)
	7	2,9 (26)	0,2 (75)
	10	2,1 (13)	0,1 (43)
Means for 1984 burn		6,1	0,5

Table 6

Indices of defoliation of grasses (all grass species combined and Themeda triandra*) at the Bontebok National Park compared with those at the Mountain Zebra and Addo Elephant National Parks. The values in parentheses are numbers of grass tufts assessed for defoliation*

Park	Time of surveys	Time since fire	Defoliation indices and sample sizes	
			Themeda triandra	All grass species
Bontebok	October 1984	Under 1 year	51 (86)	44 (131)
Bontebok	Oct. 1984 & Nov. 1985	1 – 2 years	11 (193)	9 (419)
Bontebok	November 1985	2 – 3 years	1 (184)	0,4 (314)
Mountain Zebra	March – May 1984 & 1985	Unburnt	13 (338)	9 (2339)
Addo Elephant	January – March 1984, 85 & 86	Unburnt	21 (426)	12 (1340)

as well as of all grass species combined. The sites at which assessments of grazing pressure in each park were made were chosen specifically because they were undergoing heavy grazing. The results therefore represent the situation in heavily grazed areas of each park, rather than the overall average degree of use. No burning programmes are applied at the Addo Elephant and Mountain Zebra National Parks.

For *Themeda triandra* and for all the grass species combined the defoliation index at the BNP within one year of burning was far higher than the values for the other parks. In contrast the value for the BNP within 2 – 3 years after burning was far lower than those for the other parks. This demonstrates the concentration of grazing pressure on the most recently burnt veld in the BNP, and the relative neglect of the more mature veld.

Differences between grass species in the degree of defoliation

In general the defoliation indices of individual grass species showed the same tendency as that noted above for all grass species combined. Values were highest

Table 7

Defoliaton indices of some grass species at the Bontebok National Park. Values in parentheses are numbers of tufts assessed for defoliation

Time of survey	October 1984	November 1985	October 1984	November 1985	November 1985
Time of fire	March 1983	March 1983	March 1984	March 1984	April 1985
Themeda triandra	22,5 (73)	0,6 (184)	52,1 (55)	3,9 (120)	48,7 (31)
Eragrostis curvula	14,8 (32)	3,8 (40)•	62,1 (36)	3,1 (58)	–
Pentaschistis eriostoma	27,8 (60)	0 (65)	66,3 (29)	0,1 (20)	66,1 (27)
Merxmuellera stricta	41,0 (22)	0,2 (26)	61,1 (26)	6,1 (38)	65,3 (29)
Ehrharta capensis	6,4 (48)	3,9 (29)	28,2 (19)	12,3 (28)	–
Sporobolus africanus	49,0 (26)	2,0 (27)	–	–	–
Pentaschistis spp.	2,0 (10)	1,3 (11)	0 (17)	3,0 (55)	4,3 (30)
Plagiochloa uniolae	–	0,8 (23)	21,4 (16)	3,9 (52)	–
Stipagrostis zeyheri	–	–	44,1 (25)	0,1 (43)	–
Ehrharta calycina	–	–	23,6 (19)	2,4 (23)	–

for the most recently burnt veld and lower for the older veld (Table 7). The exception to this rule were the *Pentaschistis* spp. (i.e. *P. airoides, P. densifolia, P. thunbergii* and *P. patula*) which were not well accepted on recently burnt veld (Table 7).

The species that had particularly high defoliation indices on the most recent burn in 1984 were *Pentaschistis eriostoma* (66%), *Eragrostis curvula* (62%), *Merxmuellera stricta* (61%) and *Themeda triandra* (52%). A step point survey conducted on the 1985 burn (8 months after the fire) showed that these species were just as heavily defoliated as they had been on the 1984 burn (see Table 7). It therefore appears that such utilisation levels are a regular occurrence on newly burnt areas.

Relationships between defoliation of the different grass species and their mean heights

It is evident from Table 7 that the relative differences between grass species in the defoliation index changed from 1984 to 1985. For example on the 1984 burn *P. eriostoma* and *S. zeyheri* were among the most heavily defoliated species in 1984. In 1985 these grasses were barely accepted and *Ehrharta capensis* was the

Table 8
Mean heights of the tallest leaves (in mm) of some common grasses at the Bontebok National Park, compared between 1984 and 1985. The values in parentheses are the numbers of tufts that were measured (1983 and 1984 burns pooled)

	Time of survey	
Species	October 1984	November 1985
Stipagrostis zeyheri	139	408
	(21)	(26)
Pentaschistis eriostoma	134	349
	(61)	(59)
Merxmuellera stricta	126	243
	(32)	(9)
Sporobolus africanus	62	169
	(20)	(7)
Plagiochloa uniolae	61	70
	(9)	(28)
Eragrostis curvula	58	144
	(40)	(59)
Themeda triandra	42	111
	(101)	(304)
Ehrharta calycina	37	–
	(19)	
Ehrharta capensis	35	62
	(64)	(13)
Pentaschistis spp.	29	53
	(26)	(15)

most heavily grazed species. As indicated below these changes are apparently linked to the change in mean grass height from 1984 to 1985.

The mean heights of the tallest leaves of each of the common grass species are shown in Table 8. The sample sizes of measured grass tufts were too small to examine the 1983 and 1984 burns separately so these results were pooled. (As noted above the mean height of all grass species combined did not differ significantly between the 1983 and 1984 burns, but did show a highly significant increase from 1984 to 1985; Table 3).

The mean heights shown in Table 8 reflect the differences between species in tuft size. *Pentaschistis eriostoma, Merxmuellera stricta* and *Stipagrostis zeyheri* typically grow in tall coarse tufts, whereas the other *Pentaschistis* species, *Ehrharta capensis, Ehrharta calycina* and *Plagiochloa uniolae* have smaller and sparser tufts. The tufts of the other species vary between these extremes.

Although the mean heights of all species increased from 1984 to 1985 the relative differences between them remained very similar.

Figure 1 shows the correlation between the defoliation indices and the mean height of each grass species as determined in the 1984 surveys. The significant positive correlation ($P < 0{,}05$) between these two variables indicates that the taller species, in particular *P. eriostoma, S. zeyheri* and *M. stricta*, were more heavily grazed than the shorter ones.

For the 1985 results (Fig. 2) the defoliation index was negatively correlated with the mean heights of the different grass species. This was because the shorter species,

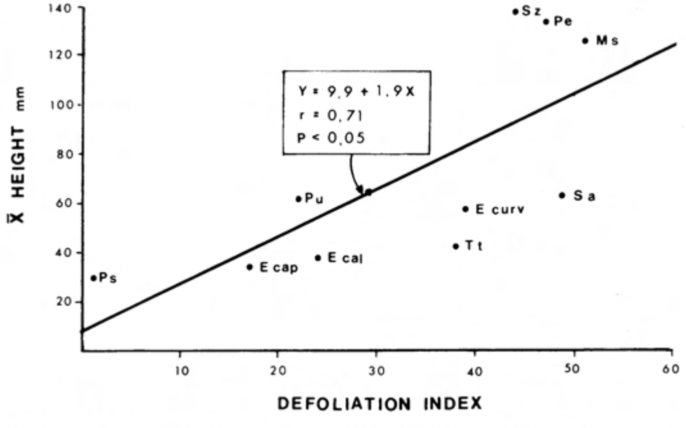

Fig. 1. Relationships between the defoliation indices of some grasses at the Bontebok National Park and their mean heights as measured in October 1984. The correlation coefficient (r) and linear regression equation relating the two variables are shown.
Sz = *Stipagrostis zeyheri*; Pe = *Pentaschistis eriostoma*,
Ms = *Merxmuellera stricta*; Pu = *Plagiochloa uniolae*,
Sa = *Sporobolus africanus*; Ecurv = *Eragrostis curvula*,
Tt = *Themeda triandra*; Ecal = *Ehrharta calycina*,
Ecap = *Ehrharta capensis*; Ps = *Pentaschistis* spp.

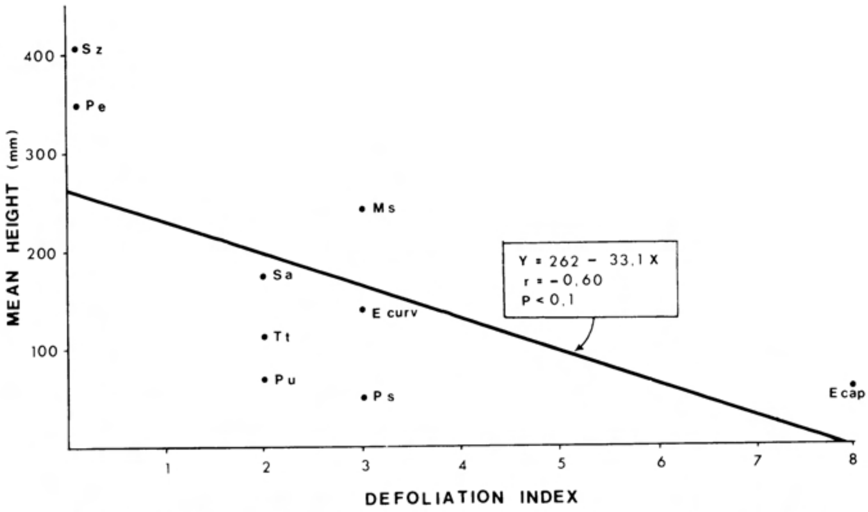

Fig. 2. Relationships between the defoliation indices of some grasses at the Bontebok National Park and their mean heights as measured in November 1985. The correlation coefficient (r) and linear regression equation relating the two variables are shown. Key to symbols as for Figure 1.

such as *Ehrharta capensis* and *Pentaschistis* spp. were at that stage relatively more heavily defoliated than the taller species.

The distribution of grass heights

Figure 3 compares the height distributions of grasses on the 1984 burn (measured 7 months after burning) with the heights measured at the same sites about one year later (20 months after burning). These heights can be compared with the range of grass heights favoured by the long grass grazers, mountain zebra and red hartebeest. In the Mountain Zebra National Park Grobler (1983) measured the heights at which grass leaves had been severed by these species. His results indicated that mountain zebras take 97% of their bites between 40 mm and 150 mm from the ground, and red hartebeest take 99% of bites between 40 mm and 120 mm. Blesbok on the other hand take 83% of bites from below 40 mm from the ground. The distribution of bite heights of bontebok has not been determined but information on their habitat preferences (Beukes 1984) suggests that they are just as dependent on short grass as the closely related blesbok.

On the new burn the maximum height of 59% off grass tufts was 40 mm or less (Fig. 3), i.e. too short for zebra or hartebeest. On the 20 month old veld only 7% of tufts were 40 mm or less in height, and a large percentage were within the range favoured by zebra and hartebeest. This suggests that zebra or hartebeest would not add significantly to the current heavy grazing pressure on the new burns, but might prolong the usefulness of the older burns by keeping the grass shorter.

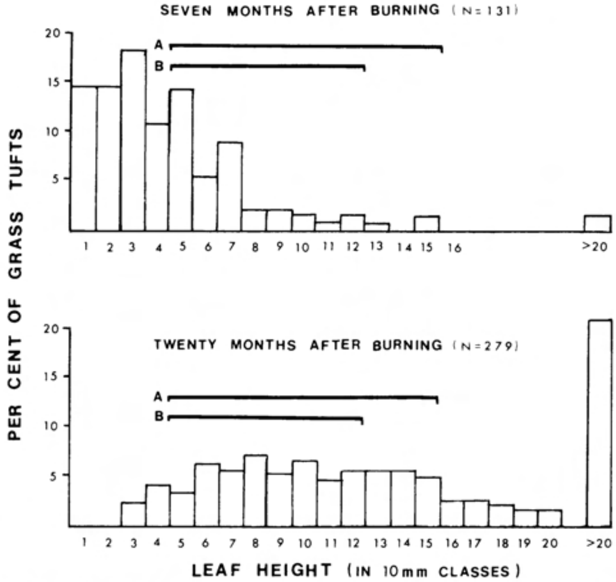

Fig. 3. Distributions of the heights of the tallest leaves of grass tufts (all species) at the Bontebok National Park (i) seven months after burning and (ii) twenty months after burning. N = numbers of tufts measured. A = height range favoured by mountain zebras. B = height range favoured by red hartebeest. (A and B from Grobler 1983).

Discussion

Compared with the other parks the degree of defoliation of grasses at the BNP on the recently burnt veld appears heavy, and the more mature veld appears underutilised. This is to be expected in view of the fact that most large herbivores are attracted to the new regrowth on burns. But the extreme contrast between the new burns and the more mature veld may well be due to the absence of long grass grazers. It is therefore recommended that 10 to 15 Cape mountain zebras be introduced to the park. If observations on their habitat use and diet composition confirm that they will utilise the mature veld more mountain zebras can be introduced. If necessary bontebok numbers can be reduced to accommodate them.

Red hartebeest were introduced into the BNP in 1960 but surprisingly they never did well, despite the fact that they were abundant in the area in historical times. The hartebeest were finally removed in 1975 (Van der Walt, De Graaff & Van Zyl 1976). However at that time they shared the park with some hundreds of bontebok and springbok. The springbok never occurred naturally in the area and have now been almost totally removed. This may well have been a case where excessive competition from an alien species, the springbok, accounted for the poor performance of the hartebeest. There may be some reason therefore, for re-introducing hartebeest.

Grobler & Marais (1967) considered that excessive grazing of newly burnt veld at the BNP would prove deleterious, leading eventually to the eradication of the palatable grass species. However, no evidence of deleterious effects were observed during the course of the present study. Those grass species that were heavily grazed on the newest burn in 1984 (*P. eriostoma, M. stricta, T. triandra, E. curvula,* and *S. zeyheri*) all showed pronounced increases in canopy spread cover over the following year (Table 2). For example the cover of *P. eriostoma* increased seven fold from 1984 to 1985. The cover of *M. stricta* was nearly six times higher in 1985 than 1984. These species also showed substantial increases in height from 1984 to 1985 (Table 8). The magnitude of the cover increases in the most heavily grazed species was greater than the value for all grass species combined (which increased by a factor of between two and three times from 1984 to 1985). It is therefore evident that heavy use of grasses during the first year after burning (in excess of 50% of leaves bitten off) does not necessarily impair their capacity to grow and survive over subsequent years.

The speed of recovery after burning is likely to be influenced by rainfall. The rainfall between the 1984 and 1985 surveys, 611 mm, was much higher than the annual mean of 515 mm. The rate of recovery during a dry year may be much slower. In the eastern Cape Martin (1966) found that the post-fire regrowth of a number of plant species, including *Themeda triandra*, was retarded by dry weather. It is therefore important that monitoring be continued to check whether grazing is having a deleterious effect over the long-term.

Of all the plant form categories the grasses were the most heavily utilised. Among the different grass species there were none that were consistently rejected by the herbivore community, and also none that were consistently favoured. Instead selection between species appeared to depend on growth stage; with the characteristically tall, coarse species being favoured on recent burns when the grasses were short, and the smaller species becoming more favoured when the grass grew taller.

In cattle the size of bites that the animals are able to take has a major influence on the efficiency of food intake (Chacon & Stobbs 1976, 1977). Bite size, in turn, is determined by sward characteristics such as leaf density and leaf/stem ratios. This offers a possible explanation for the change in selection between the tall and short grass species. In 1984 when all the grass species were short, the taller species may have allowed larger bite sizes, so permitting a more efficient rate of food intake than the smaller species. As the heights of all grasses increased from 1984 to 1985 the smaller species may have reached a size that permitted a more efficient rate of food intake, causing them to be favoured over the taller species, which may by then have become too coarse, and low in nutrient content.

Once they became mature the tall species *P. eriostoma* and *S. zeyheri* were virtually ungrazed. In the prolonged absence of fire these species may have a competitive advantage over the smaller species. *P. eriostoma* does in fact form almost exclusive stands on some of the blocks in the park that have long been protected from fires. It is also noteworthy that on the 1983 burn the cover of the smaller species *Ehrharta capensis, Pentaschistis* spp., and *Plagiochloa uniolae* actually decreased from 1984 to 1985, whereas the cover of all the larger species showed and increase (Table 2). This is an aspect that needs to be confirmed by long-term monitoring.

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