

## PASTURE COMPOSITION UNDER MIXED SHEEP AND GOAT GRAZING ON HILL COUNTRY

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### Abstract

Hill country pasture was grazed by the following ratios of goats and sheep from 1979-1 983: 100% goats (Goat 100), 66% goats and 34% sheep (Goat 66), 33% goats and 67% sheep (Goat 33), 100% set-stocked sheep (Sheep 100) and 100% mob-stocked sheep. Changes in botanical composition, herbage mass and herbage accumulation rate were measured by sample dissection, visual estimation and trimmed enclosure cages respectively on three slope classes (banks, slopes and tracks). Pastures grazed by goats developed Yorkshire fog (*Holcus lanatus*)-white clover (*Trifolium repens* L.) associations with strong white clover growth on all slope classes unlike sheep-grazed pastures which contained little white clover and were dominated by perennial ryegrass (*Lolium perenne* L.) and browntop (*Agrostis tenuis* Sibth.). The herbage mass of 3000, 1830, 1410 kg DM/ha on banks, slopes and tracks respectively for Sheep 100 pastures contrasted with that on the Goat 100 pastures of 2030, 3750 and 4300 kg DM/ha. White clover was enhanced on all slope classes in the Goat 100 treatment. Annual herbage accumulation was greater on the Goat 100 than Sheep 100 pastures, 13.9 and 11.2 t DM/ha respectively. There was a close association between increased annual white clover accumulation and total herbage accumulation. The complementary nature of sheep and goat grazing behaviours suggests the possibility of increased meat and fibre production from mixed grazing. The implications of these results for future research are discussed.

Keywords: Sheep, goats, herbage mass, herbage accumulation rate, botanical composition, slope classes, white clover (*Trifolium repens* L.), perennial ryegrass (*Lolium perenne* L.), Yorkshire fog (*Holcus lanatus*), browntop (*Agrostis tenuis* Sibth.).

### INTRODUCTION

The low legume content of New Zealand hill country pastures remains a problem despite phosphate application, oversowing and improved grazing management (Suckling 1975). Tahora white clover (*Trifolium repens* L.) has been bred for persistence in moist hill country and may contribute to improved legume growth. However, grazing with goats, or a combination of goats and sheep may also offer improved legume performance.

The value of goats for weed control has been reported by Batten (1979), Lambert *et al.* (1981) and Radcliffe (1984). Weed control occurs because of the goat's dietary preferences (Clark *et al.* 1982), but these same preferences have important effects on pasture grasses and clovers.

This paper discusses the role of goats and combinations of sheep and goats in changing pasture composition and production, especially in relation to white clover and the physiographic zones (hereafter called slope classes) of tracks (paths), slopes and banks as defined by Rumball & Esler (1968).

### METHODS

In early 1979 areas of previously sprayed, dead gorse were burned and fenced into approximately 1 ha paddocks. Grazing treatments were unreplicated and are described in Table 1. Full details of pastures, soils and animals are given by Lambert *et al.* (1981), weed measurements (Rolston *et al.* 1981), and diet selection (Clark *et al.* 1982). Briefly, pastures were dominated by browntop (*Agrostis*

Table 1: TREATMENT DESCRIPTIONS AND STOCKING RATES (No./ha) USED IN EACH TREATMENT

Treatment	Apr 79-Aug 80 <sup>1</sup>		Aug 80-Dec 80		Dec 80-Mar 83 <sup>2</sup>	
	Goats	Sheep	Goats	Sheep	Goats	Sheep
Goat 100, all goats, set-stocked	18	0	22	0	33	0
Goat 66, 66% goats, 33% sheep set-stocked	12	3	13	4	22	4
Goat 33, 33% goats, 66% sheep set-stocked	6	6	7	7	11	7
Sheep 100, all sheep, set-stocked	0	0	0	11	0	11
Sheep mob grazed, all sheep mob-grazed 6-7 times/year	0	19 <sup>3</sup>	0	21 <sup>3</sup>	0	21 <sup>3</sup>

<sup>1</sup> April 1979 to August 1980, 9 su.ha<sup>-1</sup>; from August 1980, 11 su.ha<sup>-1</sup>.

<sup>2</sup> April 1979 to December 1980, goats = 0.5 su and from December 1980, goats = 0.33 su.

<sup>3</sup> Calculated on an annual basis.

*tenuis* Sibth.) and sweet vernal (*Anthoxanthum odoratum* L.) with a small leaved, prostrate white clover and dense gorse seedling establishment. Sheep are Romney breeding ewes, mated in early April at 50-60 kg liveweight; goats are feral does mated to a Saanen buck in late April at 20-25 kg liveweight. Soils are formed on sandy siltstone with a fertiliser application of 250 kg/ha superphosphate since 1975.

Six, 0.5 m<sup>2</sup> enclosure frames were placed on track (<12°), slope (13-25°) and bank (>25°) classes in each paddock and harvested by a 'trim' technique 6-7 times each year. Herbage mass was estimated by visual assessment calibrated against cut standards. Herbage composition on offer was estimated by dissection of cut samples from line transects in each paddock in December 1982 and by 'first hit' point analysis bi-monthly throughout the trial.

### GRAZING BEHAVIOUR

Diet selection (Clark *et al.* 1982) and grazing behaviour observations (Lambert *et al.* 1981) showed that goats strongly rejected white clover while sheep grazed it in proportion to its presence in the sward. In addition, goats grazed steep banks in preference to the slopes and tracks grazed by sheep. Grass was a preferred feed for goats, especially flower- and seed-heads. Upper layers of herbage were removed and patch-grazing, a characteristic of sheep behaviour was absent. These differences in grazing behaviour produced important differences in botanical composition, herbage mass and herbage accumulation on offer during the four years of the experiment.

### BOTANICAL COMPOSITION

After three years, the Goat 100 treatment was predominantly Yorkshire fog (*Holcus lanatus*) and white clover on the tracks and slopes with browntop and white clover on the banks (Table 2). The Sheep 100 treatment was predominantly perennial ryegrass (*Lolium perenne* L.) and Poa (*Poa* spp) on the tracks, and browntop on the slopes and banks; white clover content was low on all slope classes. The Goat 66 treatment developed a Yorkshire fog-white clover mixture on the tracks with less white clover than the Goat 100. The browntop on the slopes and banks was associated with a higher white clover content than the Sheep 100 treatment. The Goat 33 treatment was not subject to full herbage dissection from line transects but 'first hit' point analysis showed that composition was intermediate between Goat 66 and Sheep 100.

We suggest that differential grazing patterns initiated the above composition changes, and other factors such as treading and plant competition maintained them. The goat's rejection of white clover reverses the normal effect of grasses shading clovers and only grass species encouraged by lax grazing, such as Yorkshire fog (Watt 1978) are able to become dominant. Lower treading damage by goats owing to less use of tracks would encourage Yorkshire fog. Edmond (reviewed by Brown & Evans 1973) showed that it was the grass least tolerant of treading. The goat's habit of grazing steep banks reduced browntop competition and led to the unusual association of browntop and clover.

In the Sheep 100 treatment grazing, treading and nutrient return were concentrated on the tracks. Consequently, ryegrass replaced Yorkshire fog, and white clover was greatly reduced. On the banks and slopes browntop was leniently grazed, increased amounts of live and dead herbage inhibited white clover growth.

Table 2: BOTANICAL COMPOSITION (%) OF BANKS, SLOPES AND TRACKS IN SHEEP 100, GOAT 66 AND GOAT 100 PASTURES IN DECEMBER 1982 (DOMINANT SPECIES ARE IN BOLD TYPE)

Species	Banks			Slopes			Tracks		
	Sheep 100	Goat 66	Goat 100	Sheep 100	Goat 66	Goat 100	Sheep 100	Goat 66	Goat 100
Perennial ryegrass	0	0	4	21	2	5	37	1	20
<b>Browntop</b>	45	19	23	33	24	5	0	19	3
Yorkshire fog	5	7	15	20	18	41	19	30	35
Poa spp.	5	0	4	8	7	16	36	19	4
White clover	2	5	21	1	10	26	3	15	33
Other	43 <sup>1</sup>	69 <sup>2</sup>	33	17	39 <sup>3</sup>	7	5	16	5

<sup>1</sup> Sweet vernal, 10.3%; Danthonia (*Notodanthonia* spp.), 9.3%; mouse-ear chickweed (*Cerastium glomeratum* Thuill), 6.7%.

<sup>2</sup> Sweet vernal, 17.6%; Suckling clover (*Trifolium dubium* Sibth.), 11.1%; mouse-ear chickweed, 9.8%.

<sup>3</sup> Sweet vernal, 13.1%; Poa, 7.0%; Suckling Clover, 5.0%; mouse-ear chickweed, 10.5%.

## HERBAGE MASS

The increased herbage mass with increasing goat:sheep ratio is shown for 1982 in Table 3, but has persisted throughout the experiment. The ability of white clover to persist in conditions of high herbage mass for four years is contrary to the decline usually seen two years after oversowing and phosphate application (Lambert *et al.* 1982). This finding suggests that white clover need not decline to a minor component on New Zealand hill country after initial pasture development. We deduce that under goat grazing more white clover tissue enters the soil as plant litter and consequently N losses will be reduced (Field & Ball 1982).

Table 3: HERBAGE MASS (kg DM/ha) ON EACH TREATMENT IN 1982 (MEAN OF 6 BI-MONTHLY ESTIMATES) AND ON BANKS, SLOPES AND TRACKS IN EACH TREATMENT ON 17 DECEMBER 1982

	Goat 100	Goat 66	Goat 33	Sheep 100
Mean herbage mass	2360	930	500	800
Herbage mass (17.12.1982)				
Banks	2030	870	1120	3000
Slopes	3750	830	1270	1830
Tracks	4300	1100	1170	1410

Evidence from Wilkinson & Gross (1965, 1967) suggests that phosphorus translocated from senescing white clover leaves can be used for new growth processes within the plant. Uptake and translocation of P is depressed by defoliation (Ueno & Williams 1967). White clover plants suffer minimal defoliation under goat grazing with increasingly severe defoliation as the proportion of sheep increases. The effect of this on the P fertiliser requirements of hill country pasture merits further investigation.

The normal pattern of herbage mass on sheep-grazed hill pastures of (banks > slopes > tracks) is reversed under goat grazing (Table 3). Consequently, pasture growing on tracks in goat treatments could utilise more fully the high soil fertility and moisture because of increased pasture mass and less bare ground than on sheep tracks.

## HERBAGE ACCUMULATION

Annual herbage accumulation was greater ( $P < 0.05$ ) in the Goat 100 than the Sheep 100 either set- or mob-stocked (Table 4). The 'trim' technique used meant that all regrowth measurements were made from a common residual. The effect of increased herbage mass on herbage accumulation (Harris 1978) would be underestimated, especially for the goat treatments that maintained a higher herbage mass (Table 3).

Further evidence for increased herbage accumulation under goat grazing comes indirectly from the herbage mass on offer. According to energy metabolism principles one breeding doe should require 0.5 times the feed required for maintenance by a breeding ewe in the present experiment. When this equivalence was used large differences in herbage mass on offer occurred in favour of the

Table 4: ANNUAL TOTAL HERBAGE AND WHITE CLOVER GROWTH (t DM/ha) ON EACH TREATMENT FOR 1980-1982 (CLOVER IN PARENTHESES)

Year	Goat 100	Goat 66	Goat 33	Sheep 100	Sheep 100 (mob)
1980	12.7 (2.3)	11.8 (2.4)	13.7 (2.4)	11.5 (2.2)	11.1 (0.7)
1981	14.9 (4.3)	13.4 (1.7)	12.6 (2.1)	10.6 (1.6)	11.9 (1.3)
1982	14.1 (1.5)	11.7 (1.6)	11.4 (1.3)	11.5 (1.4)	8.9 (1.0)
Mean	13.9 (2.70)	12.3 (1.67)	12.6 (1.93)	11.2 (1.73)	10.6 (1.0)

Goat 100 and Goat 66 treatments. A change to 1 goat = 0.33 sheep stock units (Table 1) reduced, but did not eliminate, these differences (Table 3).

The presence of feed supplies consumed by goats but not sheep could not account for this difference; nor could any evidence for a lower maintenance requirement of goats be found in the literature. We conclude that herbage accumulation was greater under goat than sheep grazing.

There is a close, positive association ( $r = 0.69$ ,  $n = 15$ ,  $P < 0.01$ ) between white clover accumulation and total herbage accumulation (equation 1).

$$Y = 9873 (\pm 712) + 1.24 (\pm 0.36) X \dots 1$$

where Y = total herbage accumulation (kg DM/ha/year)

X = white clover accumulation (kg DM/ha/year)

This suggests that improved N fixation under goat grazing may be responsible for some of the extra pasture grown. Acetylene reduction measurements on 8 January 1981 gave values of 0.20, 0.24, 0.22 and 0.06 kg N/ha/day for Goat 100, Goat 66, Goat 33 and Sheep 100 treatments respectively.

## ADVANTAGES OF MIXED GRAZING

The higher white clover content and herbage mass (Goat 66) coupled with a low sheep stocking rate suggest that ewes and lambs grazing this pasture should grow particularly well. Although lamb numbers were few, they were consistently 5 kg heavier at weaning than those on the other two sheep treatments; ewes were also heavier. No complementary effects were detected on doe or kid performance.

A very simple model, not presented here, using grazing behaviour results, predicted that mixed grazing of sheep and goats will give higher production of meat and fibre than from either species alone. This will be enhanced when diverse slope classes exist and weeds acceptable to goats but not sheep occur. These benefits are additional to those from goats as a weed control agent.

Certain disadvantages with solely goat grazing include the change to pasture species such as Yorkshire fog which may be difficult to utilise if sheep are subsequently grazed. Goats may dig up small areas during the autumn and graze buried white clover and browntop stolons. Such sites may lead to the germination of weed species. Digging did not occur where browse or seedhead material was accessible.

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## IMPLICATIONS

The results of this experiment suggest ways of increasing hill country pasture and animal production and point to a novel way of manipulating white clover content. We put forward a number of hypothesis for further experimentation.

(1) The grazing behaviour of goats leads to changes in hill country pasture composition. Reduction of grass competition on white clover on all slope classes gives higher clover growth.

(2) We postulate that increased clover growth gives increased N fixation and hence pasture growth. The usual negative feedback of extra grass growth on clover does not appear to occur because grass is continually removed in preference to clover.

(3) Under goat grazing greater herbage mass on tracks enables increased pasture growth through better use of soil fertility and moisture.

(4) The translocation of P within a lightly grazed clover plant may enhance its P economy and reduce the amount of applied P needed to maintain a given clover level.

(5) The complementary grazing of sheep and goats suggests that meat and fibre production from hill country may be increased by mixed grazing.

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## REFERENCES

- Batten, G.J. 1979: *Proc. 32nd N.Z. Weed and Pest Cont. Conf.*: 292-296.  
Brown, K.R.; Evans, P.S. 1973: *N.Z. J. exp. Agric.* 1: 217-226.  
Clark, D.A.; Lambert, M.G.; Rolston, M.P.; Dymock, N. 1982: *Proc. N.Z. Soc. Anim. Prod.* 42: 155-157.  
Field, T.R.O.; Ball, P.R. 1982: *Proc. N.Z. Grassld Ass.* 43: 64-69.  
Harris, W. 1978: In "Plant relations in pasture" ed. J.R.Wilson. CSIRO, Melbourne.  
Lambert, M.G.; Clark, D.A.; Rolston, M.P. 1981: *Proc. Ruakura Fmrs. Conf.* 33: 167-171.  
\_\_\_\_\_; Luscombe, P.C.; Clark, D.A. 1982: *Proc. N.Z. Grassld Ass.* 43: 153-160.  
Radcliffe, J. 1984: *Proc. N.Z. Grassld Ass.* 45:  
Rolston, M.P.; Lambert, M.G.; Clark, D.A.; Devantier, B.P. 1981: *Proc. 34th N.Z. Weed and Pest Cont. Conf.*: 117-121.  
Rumball, P.J.; Esler, A.E. 1968: *N.Z. J. agric. Res.* 11: 575-588.  
Suckling, F.E.T. 1975: *N.Z. J. exp. Agric.* 3: 351-436.  
Ueno, M.; Williams, R.D. 1967: *J. Brit. Grassld Soc.* 22: 165-169.  
Watt, Trudy A. 1978: *Herb. Abs.* 48: 195-204,  
Wilkinson, S.R.; Gross, C.F. 1965: *Agronomy J.* 57: 357-360.  
\_\_\_\_\_. 1967: *Ibid* 59: 372-374.