The effect of sheep and goat grazing on variegated thistle (*Silybum marianum*) populations in annual pastures

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Summary

The effect of sheep and goat grazing on variegated thistle was studied over two years when sheep alone was compared with two ratios of sheep and goats. Measurements were taken on pasture production, thistle plants and thistle seeds in soil. Thistle measurements along a fixed transect included height and width, eaten score, capitula number and number of flowering stems eaten.

In each of the two years, sheep ate little variegated thistle whereas goats significantly (P<0.001) contained plant size and consumed all capitula (year 2; mature capitula per plant 5.41 v 0.0 for sheep and goats respectively). After two years, viable seed reserves in soil were 497 ± 157 in the sheep treatments and 126 ± 66 in the goat treatments (P<0.05) with no difference between a high or low ratio of goats.

It was concluded that sheep had relatively little impact on variegated thistle whereas goats preferentially grazed the thistle. The goats were particularly effective in reducing the number of capitula and the number of capitula consumed was a function of goat grazing pressure. Removal of capitula would reduce seed production and subsequent population of the thistle.

Introduction

Variegated thistle (*Silybum marianum* (L.) Gaertner) is a widespread weed of pastures in the tablelands and slopes of New South Wales and Victoria where it reduces pasture growth and accessibility to animals (Auld *et al.* 1987). Successful control in the medium term requires the depletion of the soil seed bank (Auld *et al.* 1987). Kajons and Holst (1977) observed that goats selectively grazed variegated thistle and suggested that animals could complement or even provide an alternative to present control techniques. This observation has been confirmed by Leigh *et al.* (1993) and others.

This paper reports on a grazing experiment over two years where sheep alone was compared with sheep and two levels of goats on a thistle infested pasture.

Materials and methods

Site

The experiment was conducted at the Agricultural Research Station, Cowra in 1992 and 1993. The paddock was a degenerated improved pasture consisting predominantly of barley grass (*Hordeum leporinum* Link), mixed grasses (brome (*Bromus molliformis* F.Lloyd), great brome (*Bromus diandrus* Roth) and wild oats (*Avena fatua* L.)), subterranean clover and variegated thistle.

Grazing management and treatments

The animals were mature, non pregnant Border Leicester × Merino ewes and mature cashmere-type, female goats. The site was divided into 9 plots each of 0.75 ha providing three replications of three grazing treatments. These were (i) sheep 100% (S); (ii) sheep 67% and goats 33% (LG) and (iii) sheep 33% and 67% goats (HG). The number of each animal species grazed was determined by their maintenance energy requirements (one goat = 0.65 sheep on a liveweight basis) and the relative abundance of forage, with a minimum of 700 kg ha^{-1}, so that the stocking density changed throughout the experiment (Table 1).

Plots were allocated at random for the first year, whereas in the second year the sheep treatment plots were retained and HG treatment allocated to the plots with highest density of thistle.

Measurements

Pasture. Dry matter (DM) estimations for each plot were obtained by the procedure of Bell *et al.* (1991) where thirty random visual assessments and five selected 0.25 m^2 pasture cuts representing the range of pasture growth were taken. Botanical composition for proportion of grass, clover, thistle, bare ground and litter cover was visually estimated at each assessment. Table 2 represents the sampling schedule.

Thistle. Three 40 m fixed transects were established in 1992 and retained for both years. Transects were located to represent average thistle density, and each contained 20-40 plants. Measurements were made early and late in the vegetative stage of thistle growth and at flowering. Thistle measurements included: (i) height and width of basal leaves (cm), (ii) eaten score 1–5 (0%, 25%, 50%, 75% eaten, and stem only remaining), (iii) capitula maturity (green – non viable seed; purple – some viable; brown – mostly viable) and (iv) number of flowering stems eaten (FSE) expressed as FSE per plant.

Seeds in soil. Eighty soil samples each of 20 mm in diameter and 75 mm deep, were

Table 1. Number of sheep and goats in each treatment.

Period	Treatment				
	Sheep	Sheep 67%	Goats 33%	Sheep 33%	Goats 67%
1992					
17 March–7 April	13	8	6	4	12
7 April–20 November	7	4	3	2	6
20 November–30 December	13	8	6	4	12
1993					
14 January–12 March	5	3	2	2	6
12 March–7 May	0	0	0	0	0
7 May–6 September	6	4	3	2	6
6 September–30 December	17	11	8	6	18

Table 2. Sampling schedule for pasture, thistle and seeds.

	Year	
	1992	1993
Pasture	11 March, 25 May, 21 July	20 July, 2 September
	10 September, 23 October	29 September, 22 November
	19 November, 19 January (1993)	16 December
Transects	25 March, 5 May	4 October, 1 November
	21 September, 10 November	16 December
Seeds	1 May, 14 January (1993)	14 January, 20 December
Seedlings	–	14 April

taken within 1 m of each transect (40 each side) after seedling establishment and following thistle seed dispersal. These were pooled to make a total of 240 soil cores per plot. Samples were washed to recover whole thistle seeds. Whole seeds were cut to determine the presence of an embryo and its potential viability.

Thistle seedlings. Quadrats (0.1 m^2) were positioned at 1 metre spacings on alternative sides of the transect and the number of seedlings determined in a width class i.e. small (0–5), medium (6–10), large (11–15) and very large (>15) cm.

Statistical analyses

Analyses of variance were used to determine differences between sheep and goat grazing treatments. Univariate and multivariate regressions were conducted with goat grazing level as the independent variable by Genstat 5.3.1 (Genstat 1993).

Results

Year 1, 1992

Plant size. There was no difference in thistle width between livestock treatments (P>0.05) whereas thistle height was reduced by goat grazing in July (P<0.01), September (P<0.01) and November (P<0.05; November height 162.3 ± 7.5 cm for the S treatments and 129.0 ± 21.2 cm and 58.7 ± 18.2 cm for LG and HG respectively). A significant positive correlation existed between thistle height at mid flowering (November) and the interaction of goat number and thistle density ($r^2 = 0.98$; P<0.01).

Thistle height (cm) = 25.5 + 0.2745 g - 0.000139 g^2 where g = m^2 thistle / goat.

Capitula. The number of capitula per plant was significantly lower in goat grazed treatments (Table 3) than in sheep grazed treatments and was a response to goat grazing pressure (m^2 thistle / goat) at mid flowering (84% green and 13% purple capitula) (Figure 1). Capitula were principally consumed by goats during the green to purple capitulum stage. In goat treatments, mid-flowering (November) total number of capitula can be predicted (P<0.05, $r^2 = 0.92$) from early-flowering measurements taken in September.

Total capitula / plant = -2.69 + 0.09 width + 0.12 g where g = m^2 thistle / goat.

Eaten. Eaten scores of thistles were significantly (P<0.01) higher in the goat treatments from the early vegetative stage through to flowering, (1.0 ± 0.01 for S; 1.5 ± 0.14 and 1.9 ± 0.14 for LG and HG respectively). Similarly, the flowering stems eaten (FSE) ratios were significantly different (P<0.01) with zero for S compared to 0.2 and 1.0 for LG and HG respectively.

Soil seeds. At the beginning of the experiment values for variegated thistle seed in the soil were not significantly different between treatments. However after seed dispersal in year 1 seed numbers were different between sheep and both goat treatments (P<0.001). Soil based seed was also related directly to total capitula per plant (Figure 1).

Pasture. Pasture mass was greater in the HG plot throughout the year and was significantly greater (P<0.05) in July and November. Pasture quality did not differ between treatments.

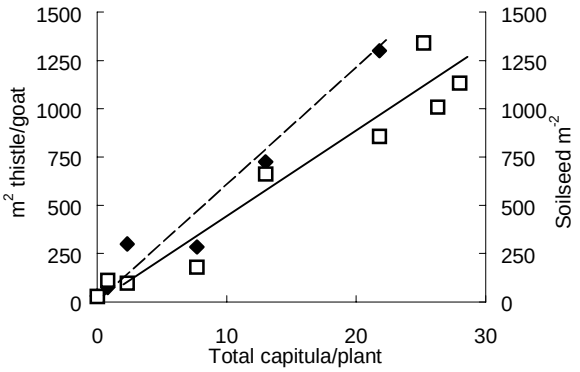

Figure 1. Relationship between m^2 thistle/goat(♦– – –♦), soilseed m^{-2} (□——□)post flowering 1992 and total capitula/plant at November 1992.

Year 2, 1993

Plant size. Thistle plants differed (P<0.001) in diameter and height between sheep and goat treatments at the end of flowering (Table 4). Taller plants had larger widths (P<0.01). Goat grazing pressure reduced both plant height and width when measured at mid flowering (P<0.05).

Capitula. The number of capitula per plant was significantly (P<0.001) lower in goat treatments with no capitula remaining at late flowering (Table 4). At early and mid flowering shorter plants had significantly (P<0.01) fewer capitula.

Eaten score. The grazing impact of goats on variegated thistle resulted in high eaten scores (P<0.01) and FSE ratios (P<0.001) (Table 4).

Table 3. Mean capitula per plant measured at early and mid flowering for Year 1.

Capitula maturity	21 September[A]					10 November				
	S	LG	HG	s.e.d.	P	S	LG	HG	s.e.d.	P
Green	1.0	0	0	0.10	<0.001	15.0	8.3	2.1	3.52	<0.05
Purple	0.7	0	0	0.03	<0.001	10.3	3.9	0.7	1.81	<0.01
Brown	0.3	0	0	0.15	<0.05	1.2	0.2	0	0.15	<0.01
Total	2.0	0	0	0.19	<0.001	26.5	12.4	2.8	5.10	<0.01

[A] S – Sheep treatment, LG – Sheep and low goats, HG – sheep and high goats.

Table 4. Means of thistle height, width and capitula production at early (E), mid (M) or late (L) flowering for Year 2.

Measurement	Time[A]	S	LG	HG	P (S v G)	P (HG v LG)	s.e.d.
Dimensions							
Width	E	36.3	30.3	20.7	<0.001	<0.05	3.50
Width	L	27.7	1.7	1.0	<0.001	n.s.	2.89
Height	E	47.7	28.3	24.0	<0.01	n.s.	5.19
Height	L	166.0	17.3	15.0	<0.001	n.s.	13.80
Capitula per plant							
Green	E	0.12	0	0	<0.001	n.s.	0.01
Green	M	1.53	0.12	0.20	<0.001	n.s.	0.25
Total	L	5.41	0	0	<0.001	n.s.	0.76
Eaten scores							
Thistle	E	1.0	1.9	2.2	<0.01	n.s.	0.31
Thistle	L	1.3	5.0	5.0	<0.001	n.s.	0.11
FSE [B]	M	0.1	0.9	0.9	<0.001	n.s.	0.07
FSE	L	0.1	1.0	1.0	<0.001	n.s.	0.03

[A] E = 4.10.93; M= 1.11.93; L= 16.12.93.

[B] FSE = Flowering stems eaten per plant.

Soil seeds. Viable seed reserves in the soil measured at post flowering (1993) were 497 ± 157 in the sheep treatments and 126 ± 66 in the goat treatments ($P<0.05$), with no difference between HG and LG. This represents an average 60% reduction in seed reserves from the beginning of the year.

Pasture. Pasture mass was greater in the HG paddock throughout the year and was significantly ($P<0.05$) greater than other treatments from mid winter to early spring when kg DM ha^{-1} was 525 ± 50 (S), 832 ± 199 (LG) and 1511 ± 216 (HG).

Thistle cover (per cent) did not differ between sheep and goat treatments in July but increased in the sheep treatments so that from early flowering it was significantly ($P<0.001$) greater than either goat treatment (Figure 2).

Seedlings. Average size of thistle seedlings in April was not different between treatments, with 80% of seedlings below 10 cm wide. Seedling number was related to soil seed reserves before germination ($P<0.001$) and to thistle plants present at early flowering ($P<0.05$).

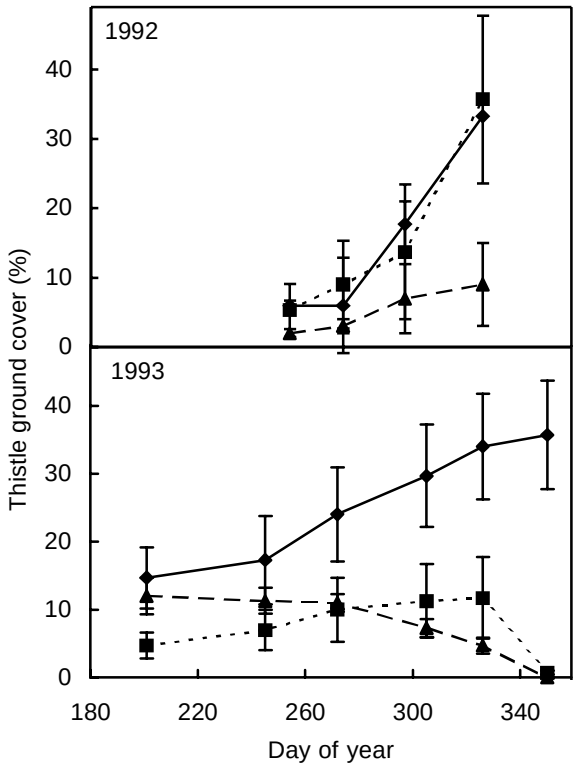

Figure 2. Comparison of thistle ground cover in 1992 and 1993 with 3 grazing treatments: sheep (♦——♦), low goats (■-----■) and high goats (▲– – –▲). Vertical bars are 2 × s.e.m.

Discussion

Grazing of variegated thistle with goats is a practical method of managing this weed. The leaf material and capitula are of higher palatability to goats than to sheep. In this study goats readily included capitula in their diet especially before maturity. The number of capitula consumed was a function of goat grazing pressure, so that complete removal of capitula was achieved by the manipulation of goat numbers early in spring to suit moderate thistle infestation levels and seasonal conditions. With heavy infestations the number of goats required may not be practical and an integrated approach is indicated. Herbicide applied in early spring will reduce thistle populations to manageable levels (Torrano *et al.* 1999). The complete prevention of seed production by grazing has already been reported for small areas (Medd 1979) and in pen studies (Leigh *et al.* 1993).

Estimates of viable seeds in the soil reflect the significant dependence ($P<0.001$) on capitula number for the maintenance of the variegated thistle population (Figure 1). It follows that soil seeds were lower in the goat treatments particularly since ingested seed is expected to have a low viability after it passes through the rumen (Holst and Allan 1996). Continued grazing with goats will reduce the thistle population. There were significant differences in the morphology of the variegated thistle as a result of grazing by sheep or goats (Figure 2). As a result of minimal defoliation by sheep it increased rapidly in height and less so in width. Throughout the same period goats modified both thistle height and width so that the resultant smaller plants had fewer capitula and these were more accessible to browsing.

We conclude that sheep have relatively little impact on variegated thistle and that, in time, profitability would be reduced (Auld *et al.* 1987). In contrast goats readily consume variegated thistle and have the potential to prevent seed production.

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