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Biological Control of Rumex obtusifolius L. by Goat Grazing

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Abstract
Effect of goat grazing on the growth, propagation and survival of a dock, *Rumex obtusifolius* L. was investigated during a period of 3 years in a permanent pasture divided into 2 parts. Three cows were grazed on one part (namely, cow-grazing plot) and 3 cows plus 4 goats were grazed on the other part (mixed-grazing plot). In both plots, 3 belt transects were set up to determine the degree of defoliation, plant height, maximum leaf length and the number of bolting stalks of adult docks. Apart from the transects, typical adults were collected to determine the dry weight of seeds in both plots in late July. Five permanent quadrats were set up to take a census of the seedlings of the dock. The adult docks were defoliated more severely up to August in the mixed-grazing plot than in the cow-grazing plot. In the former plot, the leaf length was shortened to 67%, the plant height was lowered to 26% and the number of bolting stalks was reduced to 41% of the respective ones in the latter plot in July. Moreover, the adults formed shorter bolting stalks in the mixed-grazing plot. This suppression of reproduction of the dock led to a decrease in the number of seedlings. In the mixed-grazing plot, the seedlings emerged at a rate of 18% of that in the cow-grazing plot in the autumn of the first grazing year and 30% in the spring of the second year. There were few differences between the survivorship curves of the dock in the two plots. A low percentage of seedlings survived during one year, although with a slightly higher rate in the mixed-grazing plot than in the cow-grazing plot. The established individuals could set numerous seeds in the latter plots. It was concluded that goats controlled *Rumex obtusifolius* effectively through a process of defoliation suppression of the propagation and decline of the population of the dock. Mixed-grazing could afford both weed control and improvement of pasture production.

Discipline: Grassland
Additional key words: demographic parameter, mixed-grazing, seed production, survival rate

Introduction

In Japan, docks create major problems in artificial grasslands. A large number of pastures have been mostly covered with these weeds, resulting in a decrease in animal production. Since cattle do not graze them, they grow up rapidly and set numerous seeds in fertile grasslands[3]. Pasture renovation is not effective due to the germination of the buried seeds and regrowth of the docks.

Cutting[4], application of herbicides and use of a chrysomelid beetle[1] have not been implemented for dock control due to the high cost, pollution of watershed and lack of frequent applications. We attempted to graze goats for the control of *Rumex obtusifolius* L. The present paper reports the effects of goat grazing on the growth, survival and propagation of this weed.

Methods

An experiment was conducted during a period of 3 years on a permanent pasture with an area of 1.4 ha, which was predominantly covered with *Poa pratense* L. and secondarily with *Dactylis glomerata* L., including a limited amount of other grasses, legumes and weeds. Population density of *R. obtusifolius* was about 8,000 individuals/ha based on a preliminary survey conducted for the experiment.

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The pasture was divided into 2 parts. Three cows grazed on one part (namely, cow-grazing plot) and 3 cows plus 4 goats grazed on the other part (mixed-grazing plot). In both plots the grazing pressure was about 1,400 kg/ha. Grazing period lasted for about 200 days between late April and early November. Fertilizer was applied at a rate of 120:90:30 kg/ha/y for $N:P_2O_5:K_2O$, respectively during the study period.

Three belt transects about 25 m long and 0.5 m wide were set up in both plots. Just before the experiment, 105 adult docks were marked by mapping in the transects. The degree of defoliation, plant height, maximum leaf length and the number of bolting stalks of the adults were monitored every month in the first year of the grazing period. The degree of defoliation was classified into 4 grades. Apart from the transects, samples of 10 typical adult docks were collected to determine the dry weight of the seeds in late July.

Five permanent quadrats (0.6 × 0.6 m) were set up in both plots. A total of 3,462 seedlings were marked by mapping every month up to the spring of the second year in the quadrats. Rapidity of their emergence was calculated by fitting to an Erlang distribution[5] using a least square method. Their survival was monitored every month for 3 years.

Results

1) Effect of goat grazing on adults of R. obtusifolius

The damage to the adult docks was much more severe in the mixed-grazing plot than in the cow-grazing plot. Fig. 1 shows the degree of defoliation of the adult docks each month. In the early period of grazing, a larger number of individuals of the dock were defoliated in the mixed-grazing plot. The tendency persisted with more severe damage in the middle period of grazing, although in the latter period of grazing, the numbers of individuals of the dock grazed in the 2 plots were almost the same. In July, which coincided with the flowering and seed-set season of the dock, about half of the individuals was grazed with more than half of the above-ground part in the mixed-grazing plot.

The severe defoliation of the docks in the mixed-grazing plot resulted in the discontinuation of their growth. Fig. 2 shows the changes in plant height and maximum leaf length of the docks. The changes were less pronounced in the mixed-grazing plot than in the cow-grazing plot. There were differences in plant height (400 mm) and maximum leaf length (61 mm) between the docks in the 2 plots in July. It was concluded that goats defoliated a larger quantity of docks between the growing and propagating seasons than cows.

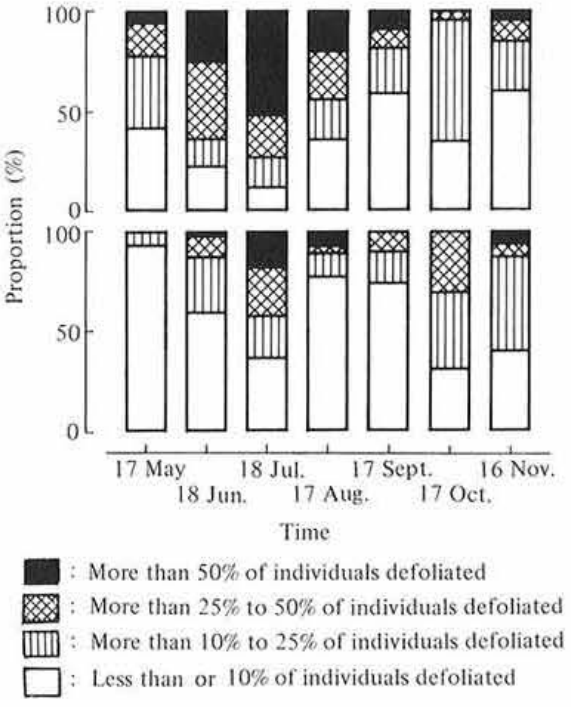

Fig. 1 Changes in the degree of defoliation of *R. obtusifolius*

Upper and lower parts represent the mixed-grazing plot and the cow-grazing plot, respectively.

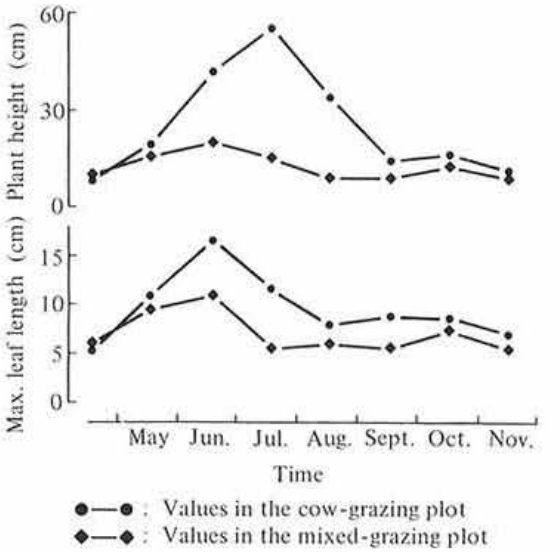

Fig. 2. Changes in plant height (upper part) and maximum leaf length (lower part) of *R. obtusifolius*

Table 1. Number of bolting stalks and dry weight of seeds of *R. obtusifolius* in late July

	No. of bolting stalks (/individual)	Dry weight of seeds (g/individual)
Cow-grazing plot	2.2	11.2
Mixed-grazing plot	0.9	0.2

Goats affected markedly the propagation of the docks. Table 1 shows the number of bolting stalks and the dry weight of the seeds of the docks in late July. In the mixed-grazing plot, a dock could form only 41% of the number of bolting stalks produced in the cow-grazing plot on the average. Moreover, the bolting stalks in the former plot were shorter and contained a small amount of seeds, suggesting that the plant height in July corresponded to the height of the bolting stalk. It was considered that goat grazing decreased the leaf size of the dock, resulting in a reduction of the production of nutrients used for propagation.

2) Effect of goat grazing on seedlings of R. obtusifolius

Suppression of propagation was followed by a decrease in the number of seedlings of the dock. Fig. 3 shows the rate of emergence of the seedlings in the 2 plots. The seedlings emerged in spring and autumn, with a peak in April and September. In the mixed-grazing plot, the number of emerged seedlings decreased to 18% of the value in the cow-grazing plot in the autumn of the first grazing year and to 30% in the spring of the second year. It was considered that the growth suppression of the dock by goat grazing led to a decrease in the number of seeds.

On the other hand, there were few differences between the survival of the seedlings in the 2 plots. Fig. 4 shows the survivorship curves of the cohorts of the dock that emerged in the spring and autumn seasons. In the 2 plots, the shape of the curves was similar to that of Deevy's type III curve[2] due to the high mortality during the seedling period which coincided with the grazing season. Only a few seedlings survived until the following year although the rate was slightly higher in the mixed-grazing plot than in the cow-grazing plot.

However, in the mixed-grazing plot, the individuals which survived for a year were small and did not form bolting stalks. In contrast, the individuals were able to reproduce in the cow-grazing plot

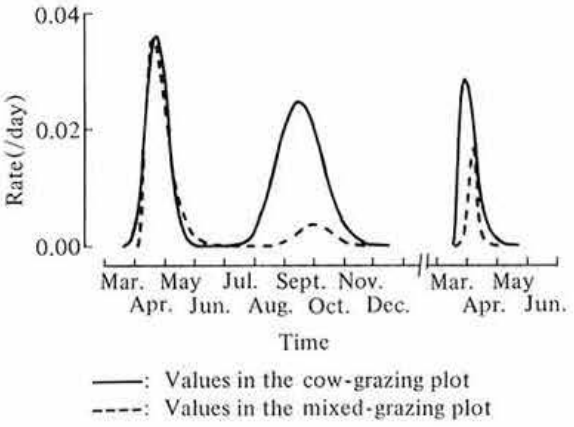

Fig. 3. Rate of emergence of *R. obtusifolius* seedlings
The total number of seedlings in the spring of the first year was substituted with unity.

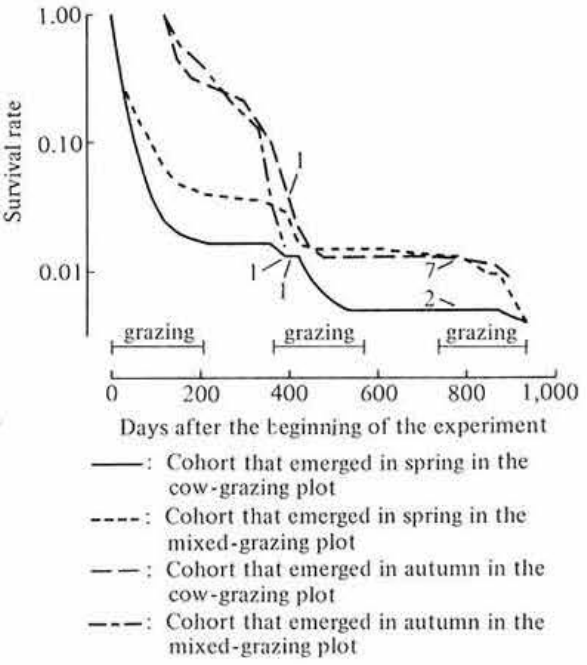

Fig. 4. Survivorship curves of *R. obtusifolius*
Figures on the curves represent the number of plants flowering.

(Fig. 4). Again, goat grazing adversely affected the propagation of the dock.

Discussion

R. obtusifolius has spread over wide areas in artificial grasslands since the 1960s when grassland improvement was implemented on a large scale in Japan. The large quantity of fertilizers and soil conditioners applied for the improvement and management of the grasslands was conducive to the establishment of

this weed on grasslands. Dock infection can also be ascribed to the fact that cows hardly defoliate the dock. The lack of efficient methods of dock control has contributed to the increase of the population of *R. obtusifolius* in grasslands.

The fluctuations of a population of a particular organism are studied based on demographic parameters, i.e. the number of living and dead individuals. The current experiment showed that goats defoliated this weed to the extent that nutrients were not available for the growth of seeds or production of new seedlings, although goat grazing did not affect the survival rate of the dock. It is considered that the dock population declined due to the lack of seedling recruitment. The effect was immediate and started to be apparent after the autumn of the first grazing year.

Decrease of the dock's leaf size removed the suppression of the growth of valuable forage crops due to the reduction of shading by the broad leaves of the weed, resulting in the improvement of pasture production. Mixed-grazing appears to be an efficient method of weed control as well as a method of improvement of pasture production.

It is important for grazing management to determine the optimum proportion of mixed-grazing of cows and goats to avoid an adverse effect on animal production. Fig. 5 shows the changes in the body weight of the cows in the first year of the experiment. Goat grazing did not exert a deleterious effect on animal production, although in the current experiment the optimum proportion of mixed-grazing was not determined. The lack of decrease of animal production was ascribed to the fact that a sufficient quantity of forage was available to the cows and goats under the grazing pressure used in the experiment. Further studies should be carried out to analyze these aspects.

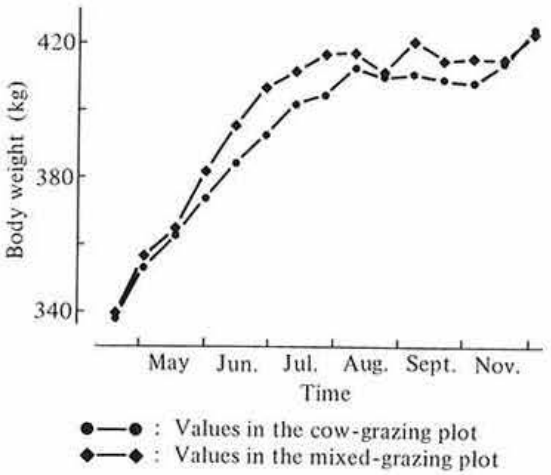

Fig. 5. Changes in body weight of cows in the first year of the experiment

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