オーチャードグラス(Dactylis glomerata L.)放牧草地におけるエゾノギシギシ(Rumex obtusifolius L.)の生態と牧草生産量との関係

誌名	日本草地学会誌
ISSN	04475933
著者	飯島, 吉晶 黒川, 勇三
巻/号	45巻3号
掲載ページ	p. 203-209
発行年月	1999年10月

Grassland Science 45 (3) : 203-209 (1999)

Relationship between Broadleaf Dock (*Rumex obtusifolius* L.) and Seasonal Yield of Orchardgrass (*Dactylis glomerata* L.) Grazing Pasture

Yoshiaki IIJIMA and Yuzo KUROKAWA

Tokyo Uninversity of Agriculture and Technology, Faculty of Agriculture, University Farm, Tsukui, Kanagawa, 220-0204 Japan

Received : May 25, 1998/Accepted : August 31, 1999

Synopsis

IIJIMA, Y. and Y. KUROKAWA (1999) : The relationship between broadleaf dock (*Rumex obtusifolius* L.) and the seasonal yield of orchardgrass grazing pasture. *Grassland Science* 45, 203-209.

A field experiment was carried out to clarify 1) the seasonal pattern of broadleaf dock growth and propagation and the factors by which these are afected, and 2) the influence of broadleaf dock on grass yields in a grazing pasture. From spring to autumn, DM yields of grass decreased and those of broadleaf dock increased. The coverage of broadleaf dock increased remarkably after the summer of 1995. The population density of plants except for seedling (plants that had more than one leaf) gradually increased during the two-year period of observation. The density of seedlings (plants that had just one or no leaves) increased during or just after the grazing periods and decreased after that time. In autumn of 1994 only, a remarkable increase in the density of seedlings occurred. The density of buried seeds of broadleaf dock increased in summer and decreased in autumn. The negative correlation between grass yields and properties of broadleaf dock was evident in each season, and became more pronounced after summer. Among the properties of broadleaf dock, the correlation of coverage of broadleaf dock with grass yields was highest. On the basis of our results, we described the seasonal patterns of growth and propagation of broadleaf dock in our grazing pasture and discussed the effects of some factors (stocking intensity, etc.) on them. The negative effect of broadleaf dock on grass yields in each season was calculated and was discussed.

Key words : Buried seeds, Grass yields, Grazing, Seasonal Change, *Rumex obtusifolius* L.

Introduction

Broadleaf dock (*Rumex obtusifolius* L.) is known as a harmful weed that affects the yield of grazing pasture. Problems related to this weed have become widespread throughout this country[3]. The species is recalcitrant because it spreads through seed and vegetative propagation. If a pasture is not cultivated many weeds of this species can survive for several years in it, producing many seeds. KOBAYASHI *et al.*[5] reported the seed production was estimated about 15,000 per plant. New plants emerge not only from seeds but from rhizomes ; the weed multiplies through vegetative propagation even when the pasture is cultivated.

Herbicides and/or repeated cultivation are available to control the weed, but these methods have the disadvantage of being vegetation-destructive. In grasslands, on steep slopes in mountainous areas, where grazing is most popular for agricultural use, more environment-conservative methods for controlling this weed are needed to facilitate sustainable agriculture in such areas.

The concept of integrated pest management (IPM) is discussed by IMURA[2]. According to his report, the prediction of the emergence and growth of weeds and their damage on production is important for applying IPM to pasture weed management. The damage to the pasture from broadleaf dock often depends on the seasonal change in the frequency of the weed[3]. Therefore, an understanding of the following issues is useful in management decisions that involve prediction of yield loss owing to broadleaf dock in a pasture.

1) Seasonal pattern of broadleaf dock growth and propagation, and factors by which these are affected.

2) Seasonal changes in influences of broadleaf dock on grass yields in a pasture.

We investigated the seasonal changes in the properties of the population of broadleaf dock and the effect of these properties on the dry weight yield of grass and other species in a grazing pasture, and

Some parts of the present study was presented at 50th (March 1995) and 51st (March 1996) meetings of the Japansese Society of Grassland Science.
Outline of this work was presented at the 18th International Grassland Congress (June 1997).

discussed the issues remarked above on the basis of this investigation.

Materials and methods

1. Pasture and grazing animals

The investigation was carried out on rotational grazing pastures at Tsukui Farm of Tokyo University of Agriculture and Technology. The experimental site was 30 a in area and located on a gentle slope on which walnut trees were planted. In the pasture, orchardgrass (*Dactylis glomerata* L.) and red top (*Agrositis alba* L.) were sown by hoof cultivation in October 1993, and again in October 1994. Compound fertilizer was topdressed at the rate of N : 48 kg, P_2O_5 : 48 kg, and K_2O : 48 kg per ha on April 29, July 20, and October 19 in 1994 ; and on May 8 and August 9 in 1995.

The outline of grazing management is shown in Table 1. From April to October, the experimental pasture was grazed continuously for 8–14 continuous days 4 times per year. Six to eight Japanese black cows and their calves were introduced to the experimental pasture at 8 A.M. and returned to the barn at 4 P.M. daily. Before and after grazing, the animals were supplemented with concentrates and/or beat pulp. Each cow was weighed at the beginning and at the end of each grazing period.

2. Sampling methods

To determine the fixed quadrat for investigation of sward characteristics, the experimental site was divided into nine equal plots. On April 20 1994, prior to the first grazing, the population densities of broadleaf dock in 30–40 quadrat of 1 m×1 m were investigated within each plot.

1) Sward characteristics and dry matter weight

Sward characteristics (sward height, coverage of each species, and population density of broadleaf dock) at the nine fixed quadrats, described above, were investigated every two weeks from spring 1994 to autumn 1995. The coverage was measured visually.

At the beginning and at the end of each grazing period, plants from the nine 1 m×1 m quadrats were cut at 3 cm above ground level ; sward characteristics in these quadrats were comparatively equal with regard to population density of broadleaf dock and coverage and height of grass and broadleaf dock. After samples were divided into grass, clover, broadleaf dock, other weeds and dead material, each sample was dried for more than 72 hours at 70℃, then was weighed. In 1995, in order to investigate the relationship between DM yields of grass and the properties of broadleaf dock, plants were cut on the additional three points where coverage of grass and broadleaf dock coverage was over 70%, respectively.

2) Buried seeds of broadleaf dock

Soil was sampled in order to count buried seeds of broadleaf dock at the nine points where the sward characteristics were approximately equivalent to those of the abovementioned fixed quadrats. Five replicates of soil at every quadrat were sampled to a depth of 5 cm, using a 100 ml core sampler, then mixed and air-dried. After the components of the air-dried soil (100 g) had been washed in the sieve (1 mm), the seeds of broadleaf dock were counted.

Results

The stocking intensity per year was 923 and 816 cow·day/ha in 1994 and 1995, respectively, and the pasture carried the highest intensity of cows in the second grazing period in each year. The body weight of the cows during the grazing period was maintained normally (Table 1).

1. Changes in biomass of pasture (Fig. 1)

The total biomass of the pasture ranged from 159 to 302 gDM/m^2 at the beginning of grazing and from

Table 1. The outline of grazing[a].

Grazing periods	Number of cattle (head)		Mean liveweight (kg/head)[b]				Stocking intensity[c] (cow·day/ha)
			at the beginning		at the end		
	Cow	Calf	Cow	Calf	Cow	Calf	
1994 21–29/Apr.	7	0	418	—	427	—	210
24/May–7/Jun.	4	1	428	42	428	52	267
12–19/Jul.	8	4	423	61	415	65	213
4–12/Oct.	8	0	405	—	414	—	240
1995 27/Apr.–6/May	7	1	430	33	439	41	233
8–19/Jun.	7	3	440	46	438	49	280
2–8/Aug.	7	3	432	75	438	83	163
1–7/Oct.	6	1	429	150	426	156	140

[a] Concentrates (0–2 kg) were fed to grazing cow.
[b] Liveweight at the beginning and the end of grazing.
[c] Number of cow were multipled by days of grazing. Number of calf were not included.

44 to 181 gDM/m^2 at the end of grazing. Grass yield at the beginning of grazing was more than 130 gDM/m^2 in May and June, and was less than 20 gDM/m^2 in September and October. The dry weight of broadleaf dock and its proportion to the total biomass at the beginning of the grazing were highest in July and August. The dry weight in autumn was less than that in the spring of 1994, but higher than that in the spring of 1995. The grass yields exceeded those of broadleaf dock from April 1994 to June 7 1995, except for the yield on July 20, 1994. After July 19 1995, the dry weight of broadleaf dock exceeded that of grass up to the end of the investigation.

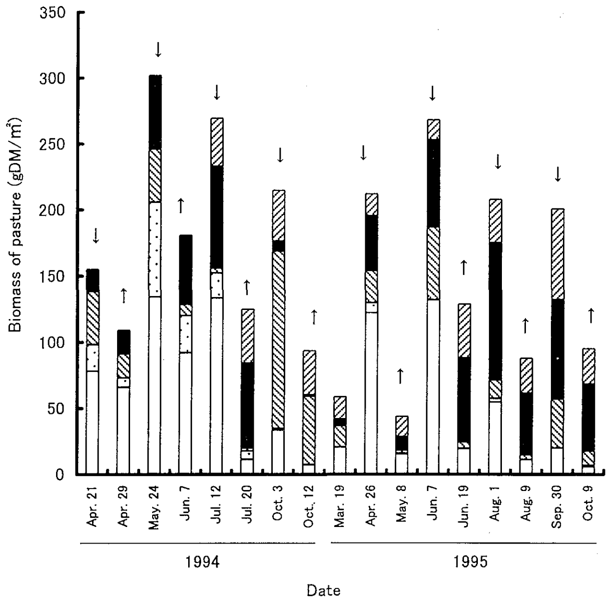

Fig. 1. Changes in biomass of pasture in 1994 and 1995.
□ Grass ⁝ White clover
▧ Other weeds ■ Broadleaf dock
▨ Dead material
↓ ; The beginning of grazing, ↑ ; The end of grazing.

The degree of decrease in grass due to grazing was higher than that of broadleaf dock in every period of grazing, and consequently the proportion of broadleaf dock at the end of grazing was higher than that at the beginning of grazing.

2. Seasonal changes in sward characteristics (Fig. 2)

From April to June the coverage of broadleaf dock was equal to that of grass, though that of broadleaf dock exceeded that of grass at the end of every period of grazing. After July, the coverage of broadleaf dock exceeded that of grass, especially after September 1995. From August to September 1994, the coverage of *Digitalia abscendens* exceeded that of grass or broadleaf dock.

From April to early June, the sward height of grass was close to that of broadleaf dock. After mid-June, that of broadleaf dock exceeded that of grass until July 1994 and August 1995, respectively. The dominance of broadleaf dock was followed by the beginning of its reproductive growth described below.

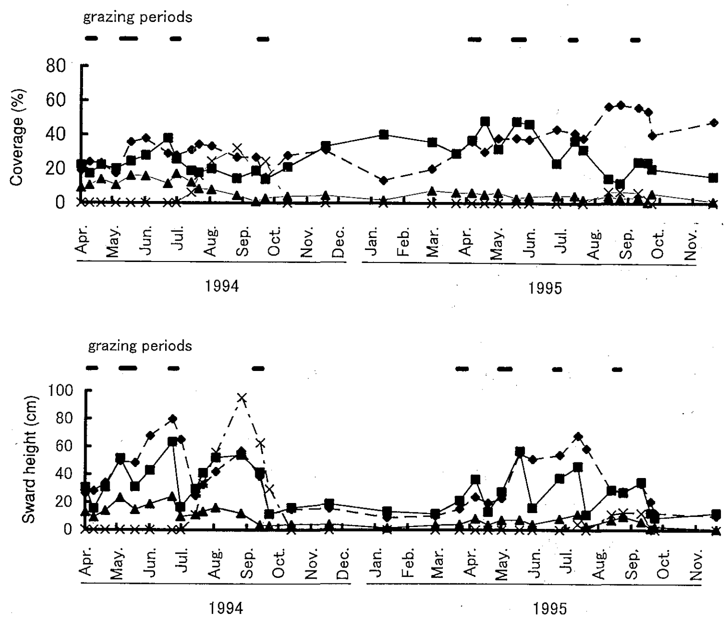

Fig. 2. Seasonal changes in the coverage and sward height of some species in the pasture.
--◆-- Broadleaf dock, —■— Orchardgrass, —▲— White clover,
--×-- *Digitaria abscendens.*

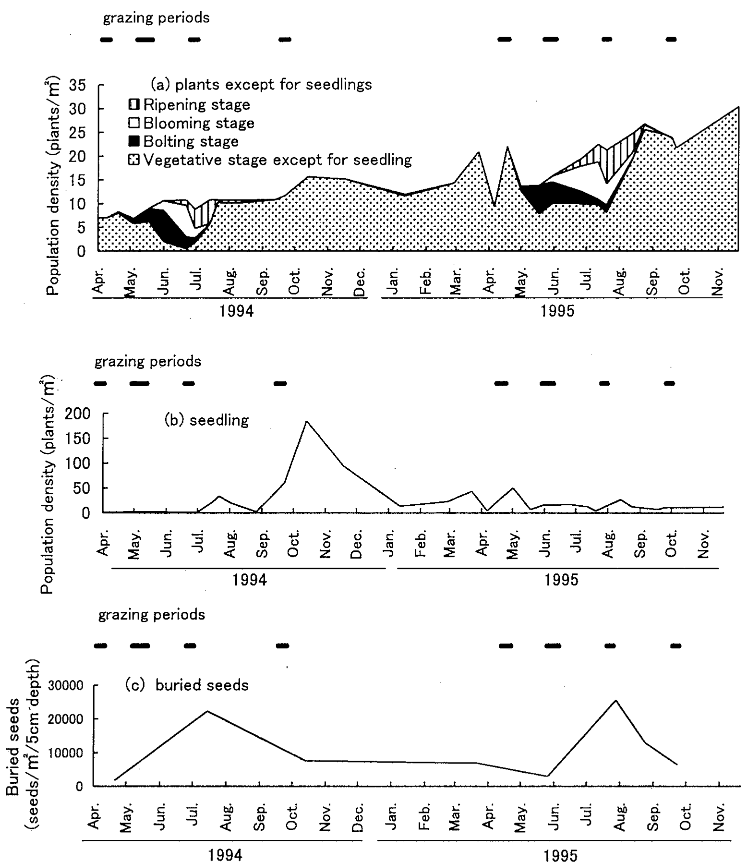

Fig. 3. Seasonal changes in density of plants except for seedling (a), seedlings (b), and buried seeds (c) of broadleaf dock in grazing pasture. Seedings : plants which had just 1 or 0 leaf.

3. Population density of broadleaf dock (Fig. 3)

In 1994, the population density of plants except for seedling of broadleaf dock (plants that had more than one leaf) was around 10 plants/m^2 from April to October. After November it increased to around 15 plants/m^2. In the spring of 1995, there occurred a sequence of sharp increases and decreases in the density, then the density increased gradually to more than 25 plants/m^2 in autumn. Plants at ripening, blooming and bolting stages appeared in early May, mid-June, and mid-July, respectively, in both years, and disappeared gradually between August and September. The population density of seedlings (plants with either one or no leaves) increased remarkably after the middle of October 1994, and reached a maximum of about 200 plants/m^2 on November 11 of that year. In 1995, there were fewer than 40 plants/m^2, excepting the counts on April 11 and May 21, and the remarkable increase observed in autumn 1994 was not observed. In the summer of both years, increases to 30 plants/m^2 were observed, but from the middle to late September the number decreased to fewer than 10 plants/m^2.

In both years, the density of buried seeds of broadleaf dock was highest in summer, with over 20,000 seeds/m^2/5 cm of soil depth. The density decreased in autumn to less than 8,000 seeds/m^2/5 cm of soil depth.

4. Relationship between grass yields and the properties of broadleaf dock

Correlation coefficients between grass yields and several properties of broadleaf dock are shown in Table 2. All coefficients were negative. After summer, dry weights, coverage, and population densities of broadleaf dock significantly correlated with grass yields. On every investigation date, the coverage of broadleaf dock showed the highest correlation with grass yields. The relationship between grass yields and coverage of broadleaf dock is shown in Fig. 4. The reduction in grass yields accompanied by increase in coverage of broadleaf dock was notable in spring.

Discussion

1. Seasonal pattern of growth and propagation of broadleaf dock and factors by which these are affected

During the spring, broadleaf dock began its vegetative growth in late May at the latest (Figs. 2 and 3). For a portion of broadleaf dock reproduction began

Table 2. Correlation coefficients between grass yields and some properties of broadleaf dock at the beginning of grazing.

Date	Correlation coefficients[a]			
	Apr. 26	Jun. 7	Aug. 1	Sep. 30
Between grass yields (gDM/m²) and broadleaf dock				
Yields (gDM/m²)	−0.231	−0.362	−0.820**	−0.657**
Coverage (%)	−0.690**	−0.456	−0.897**	−0.790**
Height (cm)	−0.259	−0.260	−0.275	−0.217
Population density[b] (plants/m²)	−0.509	−0.241	−0.789**	−0.607*

[a] * and ** indicate $p<0.05$ and $p<0.01$, respectively.

[b] Population density indicates the number of seedlings+mature plants.

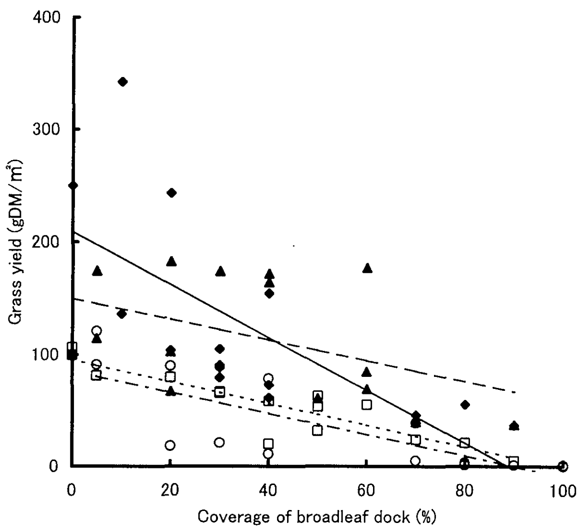

Fig. 4. Relationships between coverage of broadleaf dock and grass yield.
◆ —— : 26/Apr., $y=209.2-2.35x$, $r=0.69^{**}$,
▲ ---- : 7/Jun., $y=150.2-0.93x$, $r=0.46$,
□ ········ : 1/Aug., $y=95.5-0.98x$, $r=0.90^{**}$,
○ -·-·- : 30/Sep., $y=85.5-0.95x$, $r=0.79^{**}$.

in early May (Fig. 3 a). After the appearance of plants at the ripening stage in mid-July, the population of broadleaf dock consisted of plants bolting, blooming, ripening, and in the vegetative stages until early October.

A fluctuated increase of the plants in the vegetative stage suggests high emergence of the weed in spring 1995. KOBAYASHI *et al.*[4] reported that plants that emerged in autumn and survived during the winter could grow more vigorously than those emerged in spring. The higher density of plants that emerged in the spring 1995 resulted in the proportion of plants in the reproductive stage to plants except for seedling in 1995 being lower than that in 1994 (Fig. 3 a). Thus, higher emergence in spring might not have resulted in higher seed production of the weed during 1995. However, it might have resulted in a rapid increase in coverage of the weed after summer 1995 (Fig. 2 a).

The repeated increase in the density of seedlings during the growing season (Fig. 3 b) suggested that the species can proliferate from April to December. Because an increase in seedlings occurred during and after grazing periods, the emergence of broadleaf dock seems to relate to low coverage of grass and other species (Figs. 2 and 3 b), and to light intensity on the ground[6,8] influenced by grazing. A remarkable increase in seedlings in the autumn of 1994 seems to have followed a decrease in the coverage of *Digitalis abscendens.* During the previous grazing, its coverage was the highest among the species in the pasture.

A decrease in the density of buried seeds in the autumn was followed by an increase in the density of seedlings in 1994, though not in 1995. Emergence is surely one of the causes of a decrease in the density of buried seeds. However, the highest population density of seedlings observed (fewer than 200 plants/m²) was much smaller than the decrease in the density of buried seeds (more than 15,000 seeds/m²) in both years. Predation by soil animals and death and decay before emergence are thought to account for the decrease in buried seeds[10]. This hypothesis will likely be confirmed by further investigation into the emergence rate and mortality of seedlings[9].

The coexistence of broadleaf dock plants that began vegetative growth and those that began reproductive growth in the same season was observed in both years, though differences were observed in the percentages of plants that underwent reproductive growth and in the number of seedlings that emerged and survived in the two years. The cause of these differences should be considered along with consideration of the differences of grass yields and the relationship between broadleaf dock and grass yields.

2. Relationship between grass and broadleaf dock

Broadleaf dock had negative effects on grass yields in every season (Table 2). Among the properties of broadleaf dock, coverage seems to be the best measure of its damage to grass yields by means of invasion or spreading.

The regression coefficients of grass yields on coverage of broadleaf dock were all negative, indicating that a higher cover of broadleaf dock leads to further decreases in grass yields (Fig. 4). Grass yields in the absence of cover of broadleaf dock (G_0) were estimated at 209, 95.5, and 85.5 gDM/m^2 on April 26, August 1, and September 30, respectively. The change in G_0 was caused by a seasonal change in the growth rate of grass. Coverage of broadleaf dock with 0 gDM/m^2 of grass yields was estimated at 90% at every date of the investigation, except that of August 1.

The amounts of reduced grass yields due to broadleaf (R) and the percentage of reduced grass yields (RR) can be estimated by means of the following equations :

$$R = G_0 - EG$$

$$RR = R/G_0 \times 100$$

where EG is the estimated grass yield using the measured cover of broadleaf dock from the regression equation in Fig. 4.

R was higher in spring (84.6 gDM/m^2) than in summer and autumn (55.3 or 32.3 gDM/m^2) because of the higher G_0 in spring. But RR was higher in summer or autumn (42.1 and 62.1%) than in spring (40.4%) because of higher coverage in summer and autumn. OSWALD and HAGGAR[7] showed the percentage reduction in seasonal yields of grass sward cut for silage to that on a weedfree sward related to an increase in coverage of broadleaf dock. In thier report, a slight positive relationship between grass yields and broadleaf dock cover was recorded due to accidental grazing, with animals avoiding the plots more heavily infested with broadleaf. The present study showed negative relationships between grass yield and broadleaf dock coverage in the grazing pasture, suggesting negative effects of broadleaf cover on grass regrowth after the previous grazing period.

Grass yields in the summer and autumn of 1995 less than those of 1994 may be a result of an increase in the coverage of broadleaf dock after the summer of 1995. The difference between years may relate to higher stocking intensity in the spring of 1995 than in 1994 (Table 1), which caused a low total biomass at the end of the grazing period (May 8, Fig. 1), and, further, may have caused a higher emergence and survival rate of seedlings after the time mentioned above.

3. Conclusion

The results of our investigation showed a seasonal pattern of growth and propagation of the broadleaf dock population. The percentage of broadleaf dock that begins reproductive growth and the survival rate of seedlings, however, may relate to the reduction in grass yields affected by grazing management. The difference in the percentages in early season may affect the growth of the broadleaf dock population in later season or following year.

Broadleaf dock cover negatively affects grass yield in the grazing pasture from spring to autumn. A higher grazing intensity leads to a much higher reduction of grass yields after the summer than in spring, because the extension of broadleaf dock cover is more vigorous during the summer when the growth rate of grass decreases.

Accurately predicting the growth and propagation of broadleaf dock and its effects on grass yields in a grazing pasture requires a quantitative clarification of the effect of grazing management on the survival and extension of the cover of seedlings.

Acknowledgments

The authors give special thanks to Yasunori Noboritate, Takafumi Monya and Yasuyo Suzuki for their help with the investigations of the present study in the experimental pasture.

The authors also thank Dr. Tetsuo Shioya for his revision of this paper.

References

1) DOYLE, C.J., A.K. OSWALD, R.J. HAGGER and F.W. KIRKHAM (1983) A mathematical modeling approach to the study of the economics of controlling *Rumex obtusifolius* in grassland. *Weed research* **24**, 183–193.
2) IMURA, O. (1992) Prediction of pest-insect occurrence with reference to the pest management in sustainable agriculture. *J. JASS* **8**, 137–148.*
3) KAWANABE, S. and S. MUKAIYAMA (1992) Analysis and Diagnosis of sown pasture vegetation. 5. Ecology of broadleaf dock (*Rumex obtusifolius* L.) in the west slope of Mt. Fuji. *J. Japan. Grassl. Sci.* **38**, 302–307.*
4) KOBAYASI, H., T. FUJINAMI and H. HIROTA (1986) An ecological study on controling broadleaf dock. 3 Life history of broadleaf dock. *Hokkaido J Grassland Science* **20**, 75–83**
5) KOBAYASI, H., T. FUJINAMI and H. HIROTA (1989) Life history of broadleaf dock (*Rumex obtusifolius* L.). *J. Japan Grassl. Sci.* **35**, (3) 206–211.*
6) NEMOTO, M. (1986) Studies on the ecological control of *Rumex obtusifolius*. II. Some factors hindering the growth. *Weed Research, Japan* **31**, 244–251.*
7) OSWALD, A.K. and R.J. HAGGAR (1983) The effects of *Rumex obtusifolius* on the seasonal yields of two mainly perennial-ryegrass swards. *Grass and Forage Science* **38**, 187–191.
8) SHIMIZU, N. and K. TAJIMA (1974) Dormancy breaking of the light sensitive seeds in temperate forage crops. I. Interaction of light and temperature in germination of

Rumex obtusifolius L. seeds. *J. Japan. Grassl. Sci.* **20**, 138–143.*

9) TERAI, K. (1991) The demography of *Rumex obtusifolius* populations in Pasture. *Weed Research, Japan* **36**, (2) 135–141.

10) WEAVER, S.E. and P.B. CAVERS (1979) Dynamics of seed populations of *Rumex crispus* and *Rumex obtusifolius* (polygonaceae) in disturbed undisturbed soils. *Journal nal of Applied Ecology* **16**, 909–917.

* : In Japanese with English summary.

** : In Japanese only. Translated title by the present authors.

要　　旨

飯島吉晶・黒川勇三（1999）：オーチャードグラス（*Dactylis glomerata* L.）放牧草地におけるエゾノギシギシ（*Rumex obtusifolius* L.）の生態と牧草生産量との関係．日草誌 **45**，203–209．
東京農工大学農学部津久井農場（220-0204 神奈川県津久井郡津久井町

放牧草地におけるエゾノギシギシの生育と繁殖の季節的パターンと，それらに対して影響を及ぼす要因について把握し，エゾノギシギシが牧草生産量に対して及ぼす影響を明らかにするため，1994年の4月から1995年の12月まで試験を行った。春から秋に進むにつれて，イネ科牧草の収量は減少し，エゾノギシギシの収量は増加した。エゾノギシギシの被度は調査期間中徐々に増加したが，特に1995年の夏以降顕著に増加した。エゾノギシギシ成個体（子葉以外に2枚以上の葉をもつ個体）の密度は調査期間中徐々に増加した。実生個体（子葉を持ちそれ以外の葉が1枚以下の個体）は放牧直後の増加とその後の減少とを繰り返し，1994年の秋には顕著な増加がみられた。埋土種子の密度は8月に高くなり，秋には減少した。イネ科牧草の収量とエゾノギシギシの特性とは，それぞれの季節で負の相関関係にあり，それらの関係は夏以降高くなった。エゾノギシギシの特性のなかで，イネ科牧草の収量と最も高い相関関係を示したのは被度であった。これらの結果をもとに，本調査を行った放牧草地におけるエゾノギシギシ生育と繁殖の季節的なパターンと，それらに対して影響を及ぼす要因（放牧強度など）およびエゾノギシギシの生態と牧草生産量との関係について考察した。

キーワード：エゾノギシギシ，季節変化，放牧草地，牧草収量，埋土種子．