

< Review >

Animal Production and Phytodiversity in Semi-natural Grasslands of the Aso Region, Japan

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ABSTRACT : In this review, we present the results of our ten years of study on beef cattle production as a means of preserving phytodiversity and landscape in the semi-natural grasslands of the Aso region of Japan. There are about 16,000 ha of semi-natural grasslands in the region. The grasslands are maintained for animal production through such activities as grazing, mowing, and controlled burning. The Shannon's diversity index values, as measured in the present study, were higher in the grazed sites than in the abandoned sites. The grazing activities thus seem to create suitable habitats for coexisting herbaceous species. The grassland grazed moderately over a long term was able to sustain more animals than the grassland unused over a long term.

Key words : Animal production, Grazing, Landscape, Phytodiversity, Rare species, Semi-natural grassland

INTRODUCTION

The Aso region is situated in the center of the Kyushu district of Japan. The region forms a 35 km square around a central point at a north latitude of 32° 53' and east longitude of 131° 5' (Fig. 1). It consists of somma, caldera, and central cone areas. The total area of the region is about 120,000 hectares. Its altitudes are 400 to 1,500 m. The caldera was formed by successive volcanic activities occurring from 300,000 to a few thousand years ago, and at present there is only an active volcano in the central cone. The region is one of the rainiest areas in Japan, with an annual precipitation of about 3,000 mm, and with most of the rainfall occurring in June and July. The annual mean air temperature is 9 to 11 degrees centigrade.

Forests compose the climax vegetation of the region. In the areas lower than 700 m altitude, the climax is evergreen broad-leaved forests of the *Camellietea japonicae*. On the other hand, in the areas

over 700 m, the climax is summer-green broad-leaved forests of the *Fagetea crenatae*. In this region, the grassland vegetation would normally be expected to change to the climax forest vegetation. However, the inhabitants of this region have controlled the succession in order to preserve the grassland vegetation for over 1,000 years for feeding horse and cattle. The semi-natural grasslands have been maintained by agricultural activities such as grazing, mowing, and controlled burning. At present, approximately 10,000 head of beef cattle are fed on the grasslands, with the main breed in the region being Japanese Brown cattle. The cow-calf operation is a major component of the agricultural production in the region.

The semi-natural grasslands are situated in the North somma, the Central cone, and the South somma. The total area is approximately 16,000 hectares. Unused and unmanaged areas of the semi-natural grasslands have been increasing, because of decreases in the price

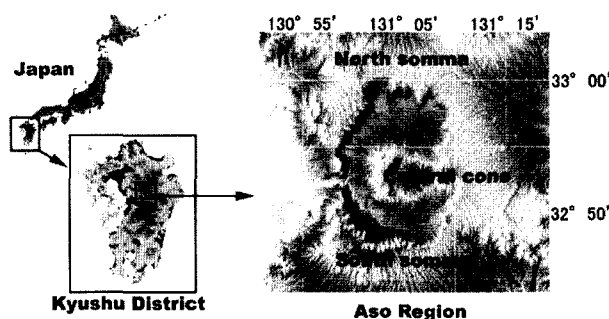


Fig. 1. A map of the Aso region in Japan.

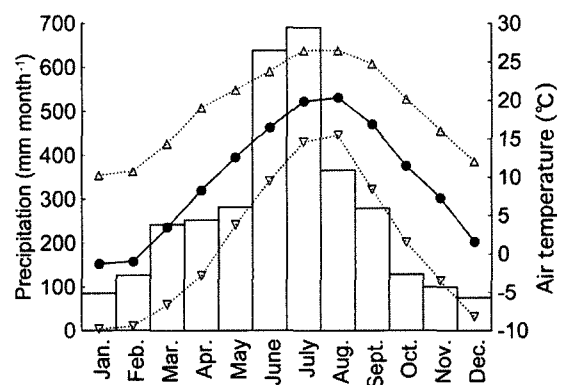


Fig. 2. Precipitation and air temperature of the Aso region (the average for 1976 to 1997).

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of cattle, decreases in the number of livestock farmers, and the aging of the farmers. These problems have grown dramatically throughout the region (Inomata *et al.* 2004). Conservation of the semi-natural grassland is thus necessary not only to preserve biodiversity but also to preserve the livestock production for the region. In addition, the semi-natural grasslands are an important sightseeing resource for the region.

In this review, we present the results of our studies on beef cattle production as a means of preserving phytodiversity and landscape in the semi-natural grasslands of the Aso region.

PRODUCTIVE CHARACTERISTICS IN THE SEMI-NATURAL GRASSLANDS

The methods used to manage semi-natural grasslands have a profound effect on the composition and characteristics of the plant community. We compared animal productivities between a short-grass type pasture (SGP) that had been grazed moderately by cows over a long period and a tall-grass type pasture (TGP) that had been used formerly as a mowing meadow (Okamoto *et al.* 1994). The SGP was dominated by *Pleioblastus chino* var. *viridis* followed by *Arundinella hirta*, *Zoysia japonica*, and 56 other species. On the other hand, the TGP was dominated by *Miscanthus sinensis* followed by *P. chino* var. *viridis*, *A. hirta*, and 37 other species. Fig. 3 shows the digestible energy (DE) and digestible crude protein (DCP) contents in the herbage consumed by grazing cows. Both the DE and DCP contents of herbage consumed on the SGP were greater than those on the TGP during a grazing season. Grazing feed

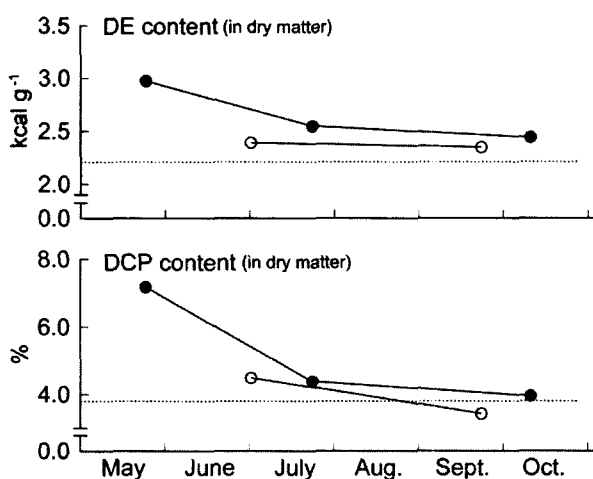


Fig. 3. Digestible energy and digestible crude protein contents in the herbage consumed by grazing cows (Okamoto *et al.* 1994a). ● and ○ show the short-grass type and tall-grass type pastures, respectively. The dashed line shows the standard requirements for maintenance of mature beef cows.

on the SGP satisfied the requirements for maintenance of mature beef cows. But that on the TGP did not satisfy the requirements of DCP content at the autumn grazing.

Fig. 4 compares the mean bite rate of grazing cows between the two pastures. In this case, the bite rate is the number of bites per unit of time during not only the period spent eating, but also those spent for selecting, moving, and halting. The mean bite rate on the SGP was faster than that on the TGP. Fig. 5 indicates the composition of the coverage of each plant height layer. In the TGP, 50% of all species had a height of over 50 cm. The differences in the bite rate between the two pastures appeared to be the result of the time spent for dietary selection. Namely, because the vertical plane in the TGP is wider than that in the SGP, animals might more frequently select food in the TGP than in the SGP.

The annual productivities in both pastures are shown in Fig. 6. The growth of the available herbage was greater in the TGP than in the SGP. The amount of herbage consumed by grazing animals was not substantially different between the two pastures. However, the degree of defoliation, *i.e.*, the use efficiency of herbage by cattle grazing was higher in the SGP (64%) than in the TGP (56%). The amount of herbage digested by grazing animals was also higher in the SGP than in the TGP. The amount of energy retention in the grazing animals was also higher in the SGP. Based on the above findings, the plant community of semi-natural grasslands might be modified to be suitable for the ingestion and growth of grazing animals by the moderate grazing.

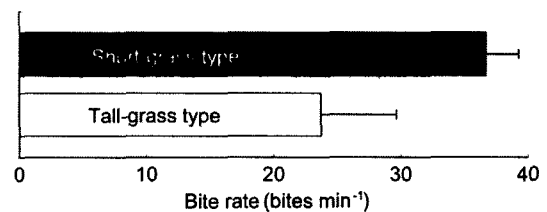


Fig. 4. Comparison of the bite rate between the two pastures (Okamoto *et al.* unpublished data).

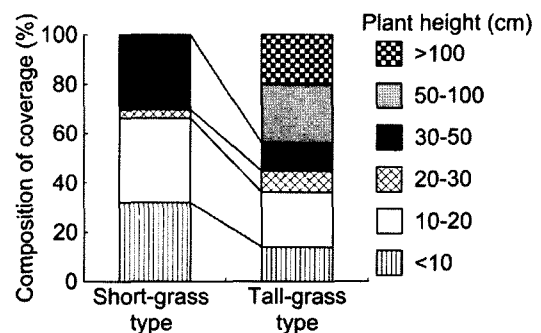


Fig. 5. The composition of coverage in each plant height layer of the community (Okamoto *et al.* 1994a).

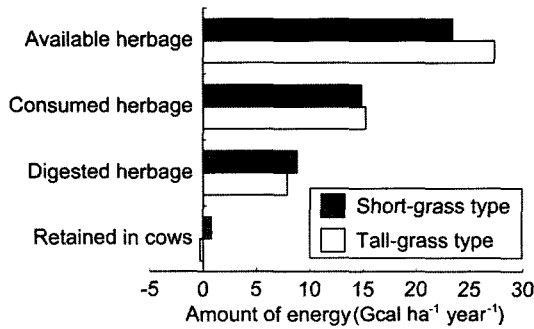


Fig. 6. Comparison of annual productivities between short-grass type and tall-grass type pastures (Okamoto *et al.*, 1994a).

COMPARISON OF THE PRODUCTIVE AND ECOLOGICAL CHARACTERISTICS BETWEEN IMPROVED AND SEMI-NATURAL GRASSLANDS

Over the last 40 years, a portion of the semi-natural grasslands of the Aso region has been improved by introducing several temperate pasture species (e.g., *Festuca arundinacea*, *Dactylis glomerata*, *Trifolium repens*, etc.). At present, there are totally 9,000 ha of improved grasslands. Grassland areas in the region consist of very undulant land. In general, most of the improved grasslands are semi-natural grasslands located on the flatlands, while the semi-natural grasslands on the slopes have not been changed. Therefore, both semi-natural and improved grasslands are distributed patchily throughout the region. To understand the fitness of both vegetation types for animal production and conservation of the environment, we investigated the productive and ecological characteristics of both improved and semi-natural grasslands (Okamoto *et al.* 1990, 1992b, 1994b, 1995, 1997, 1998a, 1998b, 2001a, and 2001b, Tsuji *et al.* 1997).

Fig. 7 shows the seasonal changes in the production of both grasslands. The herbage production in the semi-natural grasslands rises in the summer, but the production is low in both the spring and late autumn. In contrast, the production in the improved grasslands was high in both the spring and late autumn, and deteriorated in summer. The joint use of both semi-natural and improved grasslands extended the annual period in which animals could feed in a pasture over that by the single use of semi-natural grasslands, because the productivity of the pasture species introduced in the improved grasslands was higher than those of the native species in the semi-natural grasslands in low temperature periods.

To compare the desirability of the vegetation for the grazing of animals between the two grasslands, we allowed the animals to graze freely on both grasslands and observed their choice of vegetation. Fig. 8 shows the diurnal pattern of grazing of cows

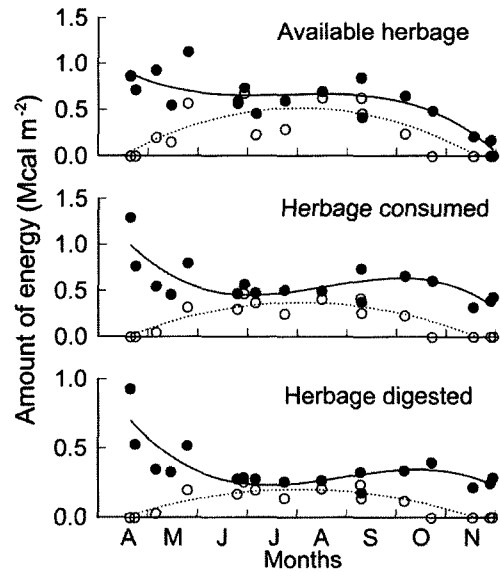


Fig. 7. Seasonal changes in the production of semi-natural and improved grasslands (Okamoto *et al.*, 1997). ● and ○ show the improved and semi-natural pastures, respectively.

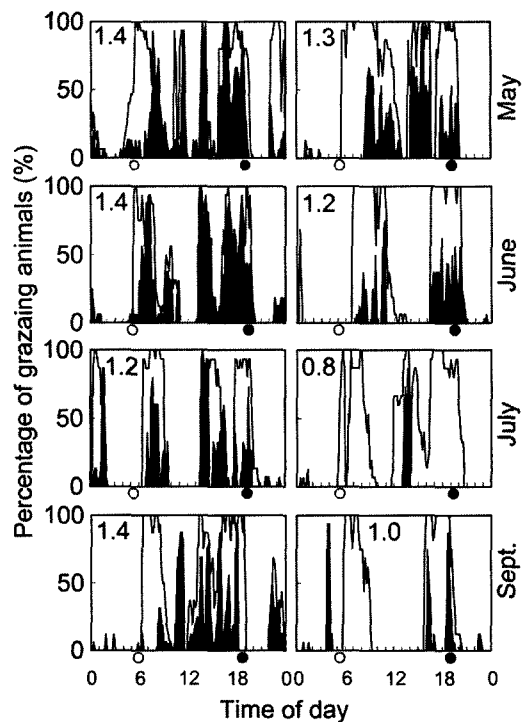


Fig. 8. Diurnal pattern of grazing of cows on both grasslands (Okamoto *et al.* 1994b). ■ and □ show the individuals grazing in the improved pasture and those in the semi-natural pasture, respectively. ○ and ● show the times of sunrise and sunset, respectively. The figures in each graph indicate the ratio of digestible herbage allowance in the improved grassland to that in the semi-natural grassland.

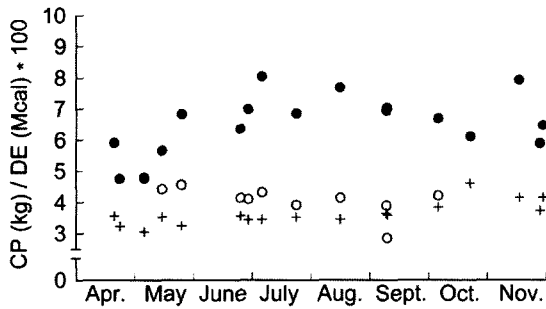


Fig. 9. The animal selects the vegetation according to its nutritional status (Okamoto *et al.* 1997). ● and ○ show the improved and semi-natural pastures, respectively. + shows the standard requirements for maintenance of mature beef cows.

on both grasslands. When the improved grasslands had greater herbage allowances, the animals grazed mainly on the improved vegetation. But even in this case, at sunrise and sunset the animals grazed mainly on the semi-natural vegetation. In this way, the animals grazed both types of vegetation selectively over a period of time throughout the day. When both allowances were similar or when the semi-natural grasslands had the greater allowance, the animals grazed mainly on the semi-natural vegetation. Fig. 9 indicates the ratio of crude protein intake to digestible energy intake. The ratios in the semi-natural grasslands were lower than those in the improved grasslands. But the ratios in the semi-natural grasslands were closer to the requirement of the animals than those in the improved grasslands. The animals selected the vegetation according to its nutritional status. In addition, semi-natural grasslands are sufficient and suitable to maintain mature cows.

RELATIONSHIP BETWEEN GRASSLAND MANAGEMENT AND VEGETATION IN SEMI-NATURAL GRASSLANDS

Although the semi-natural grasslands are maintained by human activities such as grazing, mowing, and burning, the relationship of the vegetation structure to the grassland management is still poorly understood. We investigated 21 study sites (Okamoto *et al.* 1992a, 2002). The sites were classified into three management types, namely, grazed grasslands, mown grasslands, and abandoned grasslands. The grazed grasslands were further classified into three types by the grazing intensity, *i.e.*, heavy grazing, moderate grazing, and light grazing. All the abandoned grasslands had been used formerly as grazing grassland.

Fig. 10 indicates the degrees of succession (DS), the number of species, and the Shannon's species diversity index (H') for each site. The extended summed dominance ratio (E- SDR_2) was used for

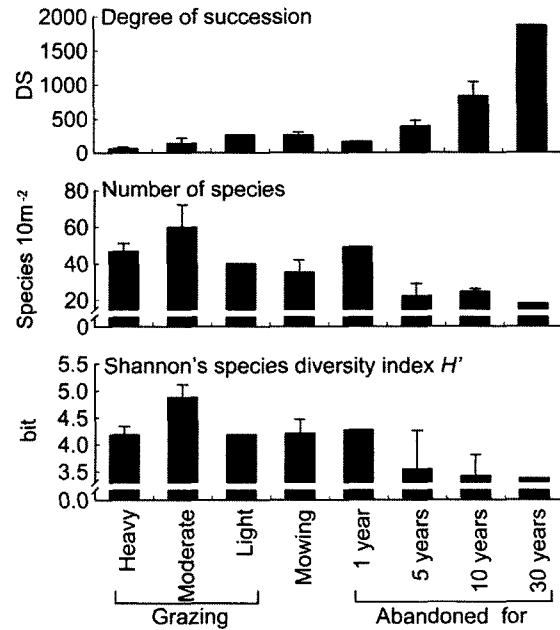


Fig. 10. The degree of succession, number of species, and species diversity index H' under different management methods (Okamoto *et al.* 2002).

the calculation of each index. The DS tended to increase with decreases in the use frequency and increases in the duration of abandonment. In the abandoned grasslands, the number of species decreased with increases in the duration of abandonment. There was a richer diversity of species in the grazing grasslands than in the mowing grasslands. The diversity of species in the moderate grazing group was richest. In the abandoned grasslands, H' decreased with increases in the duration of abandonment. The grasslands grazed moderately were most diverse in the H' . Fig. 11 indicates the composition of the coverage for each plant height layer. In the heavy grazing grasslands, more than 50% of the coverage was made

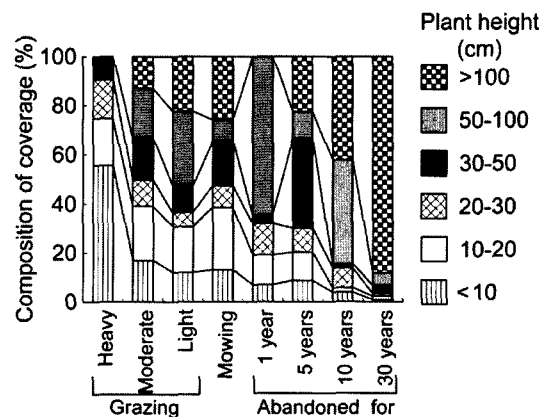


Fig. 11. The composition in each plant height layer of the community under different management methods (Okamoto *et al.* 2002).

up of species less than 10 cm in height. In the moderate grazing grasslands, the coverage was similar among layers. In the grasslands abandoned for 30 years, the coverage consisted mostly of species taller than 50 cm. As mentioned above, grazing uses, and particularly moderate uses, seemed to contribute to creating a habitat suitable for the coexistence of many herbaceous species.

PRESERVATION OF LANDSCAPE AND RARE SPECIES OF THE SEMI-NATURAL GRASSLANDS

Successive grazing and trampling by animals lead to the domination of *Zoysia japonica* and several other species that are tolerant to such rough treatment. Thus grazing management maintains a smooth, lawn-like landscape. Fig. 12 indicates the dominance ratios of several rare herbaceous species under different types of management. *Pulsatilla cernua* was observed only in the grazed grasslands. Because this species contains a weak poison, animals avoid it during grazing, which gives *P. cernua* a survival advantage under grazing conditions. To preserve *P. cernua*, grazing management is very important. The burning management scorched the surface of the grasslands. After burning, however, there are several plants which bloom immediately, such as *Viola orientalis*. In fact, this species was observed only in the burned grasslands. *V. orientalis* blooms immediately prior to the canopy formation of tall plants such as *Miscanthus sinensis*, and is therefore known as a spring ephemeral plant. Burning management is necessary to conserve *V. orientalis*. The dominance rate of *Achillea sibirica* var. *brevidens* was higher in the grazed or mown grasslands than in the abandoned grasslands. This species can survive under moderate disturbances of the grassland community, such as grazing and mowing. That is, it can survive as long as tall plants such as *M. sinensis* are inhibited.

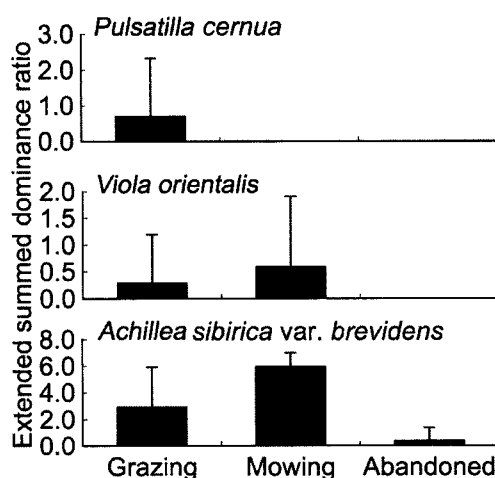


Fig. 12. Dominance ratios of several rare herbaceous species under different management methods (Okamoto *et al.* 2002).

CONCLUSIONS

1. The plant community of the semi-natural grasslands may be changed to a suitable structure for the ingestion of grazing cows by the moderate grazing.
2. When mature cows are provided simultaneously both semi-natural and improved grasslands, they may selectively graze both vegetations according to their herbage allowances and herbage nutrients.
3. Semi-natural grasslands are sufficient and suitable to maintain mature cows.
4. Use of both semi-natural and improved grasslands will enable a longer annual availability for grazing use.
5. Moderate use seems to create more suitable habitats for the coexistence of different herbaceous species in semi-natural grasslands.
6. In semi-natural grasslands, the vegetation and its phytodiversity have been maintained by artificial disturbances such as grazing, mowing, and burning.
7. The human activities related with animal production seem to be an essential element to preserve the semi-natural grassland ecosystems.

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