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Tohoku Journal of Agricultural Research
Vol. 55 No. 1-2, November 2004
Printed in Japan

Grazing Use of Native Pastures by Beef Cattle in Japan: Recent Researches on Plant-animal Interactions in Native Pastures

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(Received, September 22, 2004)

Summary

Understandings of plant-animal interactions are vital for adequate control of vegetation and animal conditions and sustainable use of the natural resources in grazing systems. In this paper, studies of plant-animal interactions that were carried out in native pastures at the Kawatabi Field Science Center (KFSC) in Tohoku University were reviewed.

1. Although forage quality of native grasses is known to lower than that of grasses in sown temperate pastures, fresh and masticated native grasses have higher ruminal degradability than dried and ground ones, indicating the importance of using fresh samples when estimating the nutritive value and ruminal digestibility. Native pastures are also suggested to supply more copper to animals than sown pastures.
2. The indigenous vegetation of the KFSC is composed of 61-80 plant species, of which cattle graze upon 44-75 species. Among these species, *Miscanthus sinensis*, *Zoysia japonica* and *Sasa palmata* are especially valuable for cattle grazing in Japanese native pastures. A new technique using plant opal phytoliths as markers is effective to obtain information on intake of individual plant species.
3. Studies of grazing impacts of cattle on plant succession are also essential to the grazing system in a native pasture. In the KFSC, shrubs such as *Weigela hortensis* have been increasing in *M. sinensis* pastures by cattle grazing, due to a decline in aboveground biomass and seed production of *M. sinensis*, and the removal of litter on the ground. Seed dispersal by grazing animals also exerts significant effects on vegetational change.
4. Beyond these studies, estimating environmental impacts of grazing on such ecosystems will require long-term investigations and quantification of nutrient flow in native pastures, including soil and soil microorganisms as variables.

For over 150 years, beef cattle in Japan have been allowed to graze on native pastures. Most of these grazing pastures are located in less favored mountain areas, and have been managed by extensive grazing systems. Due to the low

animal productivity in native pastures (e.g. daily gain of body weight) compared to sown grasslands (Hayashi *et al.*, 1966, 1967, 1979), the area of grazing native pastures declined during the 1960s-80s, replaced by sown pastures. However, alongside growing concerns involving conservation and the importance of sustainable, extensive production systems in Japan, attention has recently focused on grazing systems of native pastures as a key element of land resource use and reinvigoration of local communities.

Understandings of plant-animal interactions are vital for adequate control of vegetation and animal conditions and sustainable use of native pastures. However, the diversity of both vegetational and topographical characteristics complicates such interactions and makes a clear understanding difficult to achieve.

We have studied plant-animal interactions in native pastures grazed by beef cattle, seeking to develop a grazing system in mountainous regions in Japan. Early researches focused on particulars of vegetation (e.g., species composition, canopy structure, and forage production) and cattle (diet selection, behavior, and beef production). Recent researches have been focusing on elucidating the mechanisms of plant-animal interactions, including the following issues: 1) nutritive value and ruminal digestibility of native grasses; 2) relationships between diet selection of animals and vegetational characteristics; and 3) effects of grazing on vegetational changes.

The objective of this paper is to review recent studies of plant-animal interactions in native pastures in Japan. Most of the studies described were carried out at the Kawatabi Field Science Center (KFSC), Graduate School of Agricultural Science, Tohoku University.

1. Nutritive Value and Ruminal Digestibility of Native Grasses

The quality of native grasses is known to be lower than that of grasses in sown temperate pastures, although such grasses contain sufficient nutrients for maintenance of body weight in nonlactating and nonpregnant beef cattle. For instance, concentration of crude protein (CP) in *Z. japonica* and *M. sinensis* in a native pasture was 69-74 g/kg DM and 71-102 g/kg DM, respectively, which was lower than that of *Dactylis glomerata* (156-171 g/kg DM) growing in the same pasture (Ogura *et al.*, 2001). A study by Kawamura *et al.* (1987) also showed lower CP concentrations for *S. palmata* (106-146 g/kg DM). Studies of trace elements in a native pasture in KFSC indicated that concentrations of copper, calcium and zinc were inadequate to satisfy the minimum requirements of steers, particularly in summer and autumn (Kawamura *et al.*, 1987), but that copper concentrations in the blood of Holstein cattle were higher when grazed in the native pasture than in a sown pasture (Sugawara *et al.*, 1983). This suggests the potential of native forage as a source of copper.

The most common method for estimating the nutritive value of forage is an analysis of chemical composition (including CP, crude fat and neutral detergent fiber) and digestibility. A dried, ground forage sample is generally used for such analysis. However, grazing animals mainly ingest green materials with high moisture content (Narita and Sugawara, 2001), meaning that the nutritional characteristics of fresh materials may differ from those of a dried and ground sample. In fact, an *in vitro* experiment (Ogura *et al.*, 1999) showed that the ruminal degradability of fresh *M. sinensis* and *Z. japonica* sampled from esophageal fistula was significantly higher than that of dried and ground, and freshly chopped samples, indicating that mastication enhances the ruminal degradability of fresh forage through the elution of soluble components by disruption of cell walls. Ogura *et al.* (2001) also demonstrated that *in sacco* ruminal degradability of CP in fresh *Z. japonica* was stable over grazing seasons, indicating that *Z. japonica* provides a stable supply of ruminal digestible nutrients for animals in native pastures. The difference in degradability may be attributable to the specific chemical and morphological characteristics of each grass species. These studies point to the importance of using fresh samples when estimating the nutritive value and ruminal digestibility of native forage (Ogura, 2001).

2. Diet Selection and Ingestive Behavior of Beef Cattle in Native Pastures

Grazing cattle must search for and harvest their food from vegetation. In native pastures, animals encounter a variety of plant species of differing canopy structures, quality and phenology. These vegetational characteristics affect diet selection and ingestive behavior.

The indigenous vegetation of the KFSC is composed of 61-80 plant species (Matsumoto and Sugawara, 1995 ; Sato, 1996), of which cattle grazed upon 44-75 species (Hasegawa *et al.*, 1973 ; Ito and Izawa, 1982 ; Matsumoto *et al.*, 1995). The number of species grazed is low in spring and high in autumn (Hasegawa *et al.*, 1973). Among these species, *M. sinensis*, *Z. japonica* and *S. palmata* are widely distributed in Japanese native pastures, and are preferred by cattle (Hasegawa *et al.*, 1973), making these grasses especially valuable for cattle grazing in Japanese native pastures. While *S. palmata* is dominant in forests and tree plantation areas in mountainous areas, where it is grazed by cattle (Kawamura *et al.*, 1987 ; Isawa *et al.*, 1992), Kawamura *et al.* (1987) found that its palatability declined when it grew under shading condition in a forest. Several chemical components such as nitrate nitrogen and/or alkaloids were implicated (Goto *et al.*, 1982), but the specific mechanism remains unclear.

Most studies of the selection of individual plant species have been based on visual observations of the behavior of grazing animals. This technique is both labor- and time-intensive and may disturb the feeding behavior of animals. In

addition to this, it may be difficult to instantaneously identify plant species ingested. To overcome these limitations, Matsumoto and Sugawara (1997) developed a new technique for estimating selection and intake of plant species by cattle in native pastures, using plant opal phytoliths as markers. The study showed that 5 native grasses (*M. sinensis*, *Z. japonica*, *S. palmata*, *Spodiopogon sibiricus* and *Arundinella hirta*) contained distinct, species-specific opal phytoliths, and that it was possible to estimate how much of each these species had been ingested by counting the number of such opal phytoliths found in feces.

Recently, Takahashi *et al.* (2004) suggested that both the vertical distribution and morphological characteristics of available forage for individual plant species were closely related to the ingestive behavior and diet selection of grazing cattle. Further studies of the relationship of the ingestive behavior of grazing animals to plant structure and the quality and vertical distribution of available forage will provide useful information on diet selection and foraging strategy of animals.

3. Effects of Grazing on Vegetational Changes

Studies of grazing impacts of cattle on plant succession are also essential to the grazing system in a native pasture. General observations indicate that cattle grazing in Japanese native pastures tends to change tall (*Miscanthus*-type) grasslands to sod (*Zoysia*-type) grasslands (e.g., Hayashi *et al.*, 1968). In the KFSC, however, cattle grazing in *M. sinensis* pastures has increased shrubs in some areas. Nishiwaki *et al.* (1993) found that microtopography affected plant succession under grazing; i.e. on concave slopes, *M. sinensis* communities changed to shrubs dominated by *W. hortensis*, whereas on convex slopes, tall pastures dominated by *M. sinensis* and *S. palmata* changed to sod pastures dominated by *Z. japonica*. Other recent research has shown that the invasion of *W. hortensis* into a tall pasture was enhanced by a decline in aboveground biomass (Shinsho and Sugawara, 2004) and seed production (Nishiwaki *et al.*, 1996) of *M. sinensis*, and by the removal of litter on the ground (Shinsho and Sugawara, 2002).

Seed dispersal by grazing animals also exerts significant effects on vegetational change. It is well known, for example, that the seeds of certain plant species are ingested by grazing animals and disseminated through the digestive tract. Watanabe *et al.* (2002) reported that the invasion of *Carex albata* into a sown pasture was due to seed dispersal by grazing animals. Seed dispersal of *Carex* spp. may occur in native pastures when animals move from a sown pasture containing such plants to a native pasture.

Such findings will help estimate the impact of animals on plant succession and contribute to sustainable grazing use of Japanese native pastures.

Conclusions

The complex interrelationships of various factors in native pastures make it difficult to predict forage production, animal intake, and vegetational change precisely. The recent studies reviewed in this paper provide new perspectives on plant-animal interactions in native pastures. Beyond these studies, estimating environmental impacts of grazing on such ecosystems will require long-term investigations and quantification of nutrient flow in native pastures, including soil and soil microorganisms as variables (e.g., Saito *et al.*, 2004). A predictive model of animal production and environmental impact based on results of past studies will help establish practices that promote the sustainable use of native pastures for cattle grazing.

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