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Long-term Trend in Pre-grazing Horizontal Distribution of Herbage Mass in Bahiagrass Pasture (*Paspalum notatum* Flügge)

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Abstract

Grazing by cattle plays a main role in development of spatial heterogeneity in pasture and through it, as well, in stability of particular grazing system. In this study the first five years (1995-1999) of a long-term trial in pre-grazing distribution of herbage mass in bahiagrass pasture, utilised under the same repeated grazing management are shown. Herbage mass was non-destructively estimated with an electronic capacitance probe at 182, 50 by 50 cm locations along 2 permanent line transects. The changes in pre-grazing horizontal distribution of herbage mass during five grazing seasons were measured always on the same position on two transects just before the beginning of each grazing period (27 occasions). The pre-grazing herbage mass shows spatially heterogeneous distribution, as it was indicated by the coefficient of variation in the range from 0.221 (August 1998) to 1.107 (September 1995) for all measurement dates. This research had also the aim to quantify the stability of sward in a long-term distribution of pre-grazing herbage mass in bahiagrass pasture, and the calculated correlation coefficient of multilinear regression ($r=0.612$) was highly significant ($p < 0.001$). Anyway, it is difficult to say weather this pasture is going to maintain the same spatial pattern of herbage mass in, for example, next five years. That is, to continue this research in the future is necessary task in obtaining more information about spatial heterogeneity of vegetation in bahiagrass pasture, and implication of agro ecological advantages to grazing systems.

Keywords: bahiagrass, Paspalum notatum, grazing, herbage mass, spatial heterogeneity

1 Introduction

Japan is located in the heavy rainfall zone, and there are no natural grasslands as the climax vegetation except for the alpine grasslands, windward grasslands, coastal grasslands and moor that cover very limited areas. In the summer, the southeast of Japan (islands Kyushu, Shikoku) records more than 24°C of mean temperature and the climate is similar to that in the subtropics. Therefore summer kill of temperate grasses and clover in this region, particularly in the lowlands is serious problem. A rainy season

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lasts for about a month and although very favourable for rice cultivation in the case of animal husbandry, it impairs hay and silage making because this season coincides with the first cutting period of grasses. Utilisation of improved artificial pastures was initiated long time ago, and concerning pasture plant species, bahiagrass (*Paspalum notatum* Flügge) was introduced from the USA and highlighted as a one of promising species in that region. It is a sod forming, warm seasonal perennial, wide spread in the low-attitude regions of southeast Japan and used for both grazing and hay (PAKIDING and HIRATA, 1999).

Grazing by cattle plays a main role in development of spatial heterogeneity in pasture and through it, as well, in stability of particular grazing system. The investigation of systems heterogeneity (the scales, processes and impact of spatial and temporal variability on system characteristics, stability and productivity) is clearly a major growing area (ILLIUS and HODGSON, 1996). Heterogeneity of pasture and the uneven distribution of herbage mass generally appear as a result of selective and patchy grazing by large herbivores. This may be also associated with spatial distribution of different forage species, with patchiness of the resource base (e.g. soil depth or nutrient content) or, most importantly, with the spatial heterogeneity or variation in sward structure resulting from prior selective grazing, (TAINTON *et al.*, 1996). Therefore, the existence of an optimal spatial and temporal scale for patch assessment and decision making is characterized by the animal and vegetation properties and to understand better these decisions require sampling of the vegetation for long enough to provide sufficiently reliable information, (GORDON and ILLIUS, 1992).

In this study the first five years of a long-term trial in pre-grazing distribution of herbage mass in bahiagrass pasture are referred. The changes in pre-grazing horizontal distribution of herbage mass during five grazing seasons (1995-1999) are shown in this paper, measured always on the same position on two transects just before the beginning of each grazing period.
However, there is a little information available about long-term distribution of herbage mass and stability of spatial pattern in bahiagrass pasture grazed by cattle.

2 Materials and Methods

2.1 Study site and grazing management

The experiment was conducted from May 1995 to October 1999 on a 1.1 ha paddock (1.1 ha) of bahiagrass *(Paspalum notatum* Flügge cv. Pensacola) pasture at the Sumiyoshi Livestock Farm (31°59'N,131°28'E), Faculty of Agriculture, Miyazaki University.

The paddock was one of five paddocks (total area=6.3 ha) rotationally grazed by Japanese Black cows. Grazing was conducted as follows: five times in 1995 (31 animals), 1996 (28-32 animals) and 1999 (30-33 animals), six times in 1997 (29-33 animals) and 1998 (31-34 animals) from May to October. The everyday grazing was daily grazing from 09.00-16.00 h. The duration of each rotational grazing period was within 2-7 days interval. The total length of grazing period was 31, 23, 22, 32 and 30 days in 1995, 1996, 1997, 1998 and 1999 respectively. The average live weight of the animals was about 450 kg.

The annual fertilization rates per ha were 81 kg N (split application in April and September), 12 kg P (April) and 19 kg K (April) in 1995; 77 kg N (March and August), 20 kg P (March) and 30 kg K (March) in 1996; 45 kg N, 20 kg P and 30 kg K (all in April) in 1997; 77 kg N (April and September), 27 kg P (April) and 40 kg K (April) in 1998; 70 kg N (April and August), 18 kg P (April) and 20 kg K (April) in 1999.

2.2 Measurements

The pre-grazing distribution of herbage mass was measured during five grazing seasons (1995-1999). Hirata and Fukuyama (1997) developed a sward-based method using an electronic capacitance probe. An electronic capacitance probe (Pasture Probe™, Mosaic System Ltd., New Zealand) was used to measure capacitance (corrected meter reading-CMR) at 1m intervals along 2 fixed transects. Each transect was 90 m long and the CMR was determined at 182 positions. At each position, the CMR was measured 5 times within an area of 50 × 50 cm and the mean value of the 5 measurements was recorded as the CMR of that place. The CMR was converted into herbage mass $(\text{gDM}(2500\text{cm}^2)^{-1})$ with height of 3 cm, using a calibration equation, which was developed for each pre-grazing occasion. The technique that we applied in this research, by using electronic capacitance probe can follow the temporal dynamics in a number of fixed locations in a pasture with relatively small amount of labor. It could also quantify well the spatial heterogeneity in herbage mass and the stability of spatial pattern of herbage mass (Hirata, 2000).

2.3 Data analysis

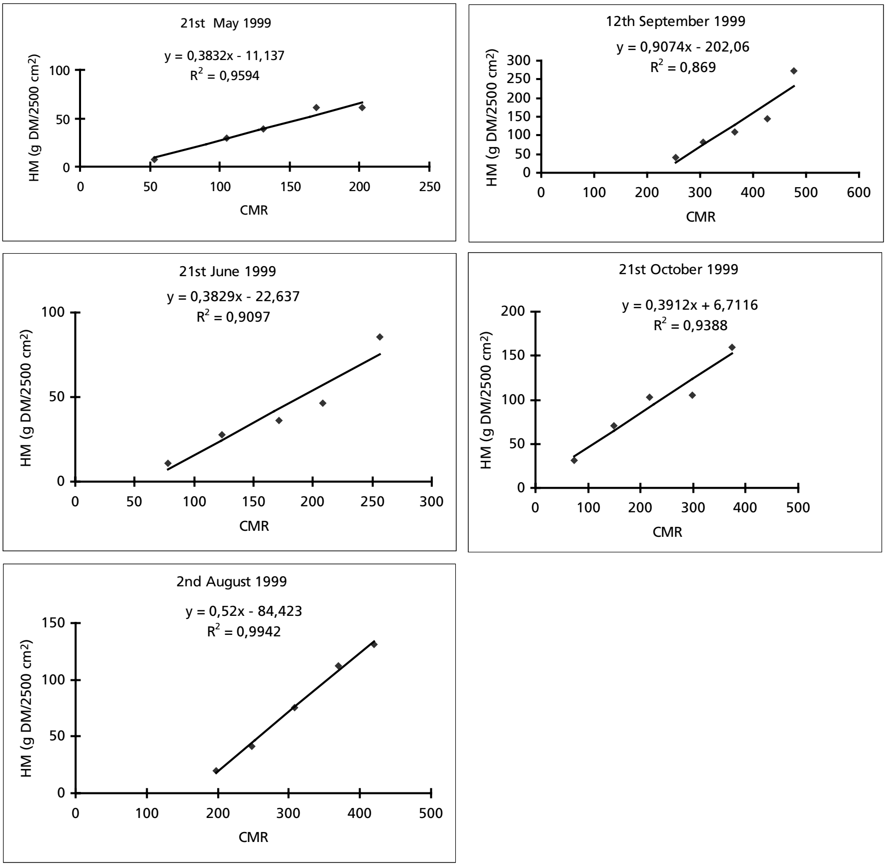
Statistical parameters: minimum, mean, maximum, standard deviation (SD) and coefficient of variation (CV) of herbage mass were calculated to show the distribution of pre-grazing herbage mass $(\text{gDM}(2500\text{cm}^2)^{-1})$ in the five years period from 1995 to 1999 on two transects.

To quantify the stability of spatial pattern of herbage mass the change in the spatial pattern between 2 measurement dates was expressed as a correlation coefficient between dates. There were 27 measurement dates, thus the correlation coefficient was calculated by comparing the HM of each date with that of 26 other dates, thus 351 calculations $({}_{27}C_2)$.

3 Results and Discussion

The relationship between herbage mass and CMR was each time highly significant $(p < 0.001)$. Some examples (pre-grazing occasions in 1999) of the relationship between the herbage mass and CMR are shown in Figure 1. The example of pre-grazing horizontal distribution of herbage mass on both transects in 1997 is shown in Figure 2, while the following statistical parameters for each grazing season (1995-1999): minimum, mean, maximum, standard deviation (SD) are shown in Figure 3.

Figure 1: Relationships between herbage mass and corrected meter reading (CMR) by an electronic capacitance probe in 1999 (example).

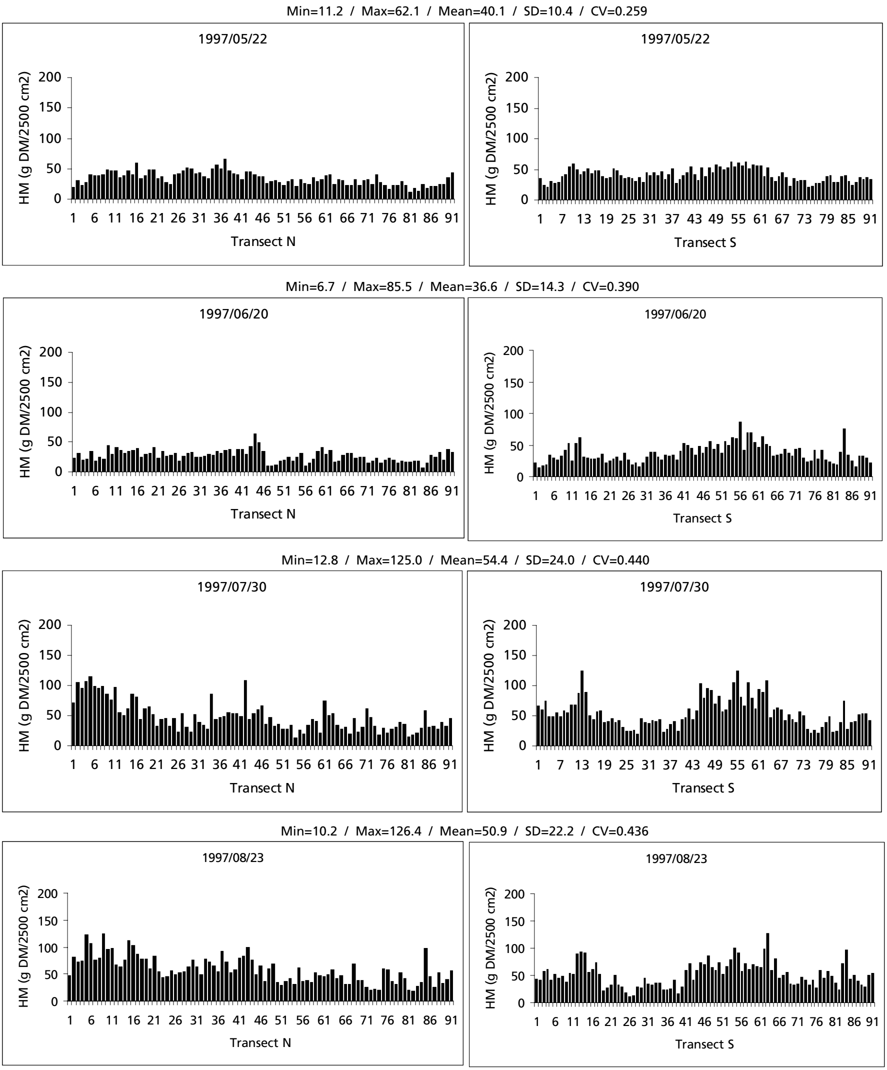


In the same figure we can see the change in these parameters for each year as follows: The HM minimum in 1995 varied from 0.0 (September/October) to13.8 (May); in 1996 from 5.0 (May) to 49.0 (September); in 1997 from 0.0 (October) to 12.8 (July); in 1998 from 12.7 (September) to 86.0 (August) and in 1999 from 12.2 (June) to 81.8 (October).

The HM maximum varied in 1995 from 36.2 (October) to 132.9 (June); in 1996 from 41.5 (June) to 193.0 (September); in 1997 from 62.1 (May) to 155.0 (October); in 1998 from 78.8 (May) to 248.0 (August) and in 1999 from 62.1 (May) to 349.4 (October).

The HM means varied in 1995 from 7.9 (October) to 45.9 (May); in 1996 from 17.2 (May) to 107.2 (September): in 1997 from 31.8 (October) to 54.4 (July); in 1998 from 54.9 (May) to 165.5 (September) and in 1999 from 31.3 (May) to 233.6 (October).

Figure 2: Pre-grazing horizontal distribution of herbage mass on two transects in 1997 (gDM$(2500\text{cm}^2)^{-1}$) (example).



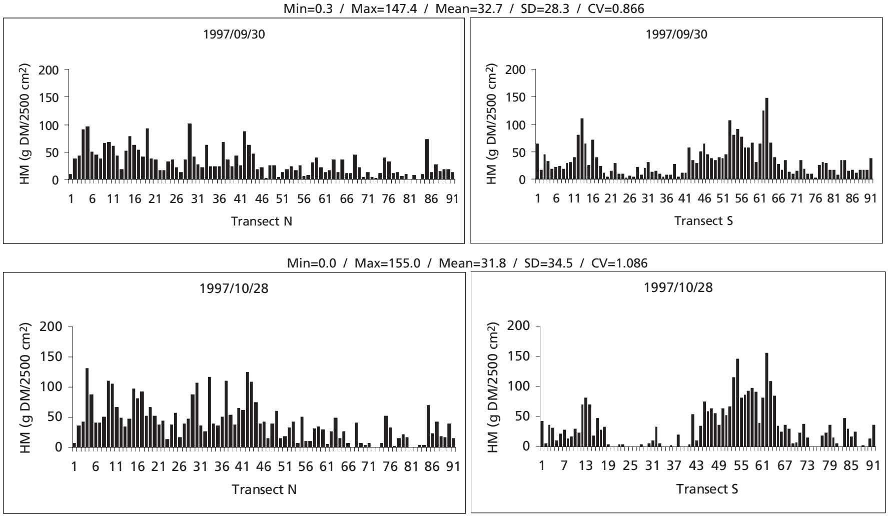
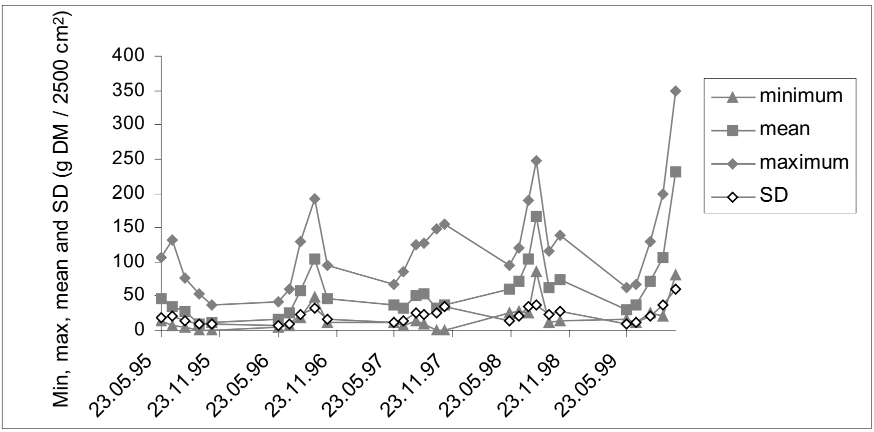


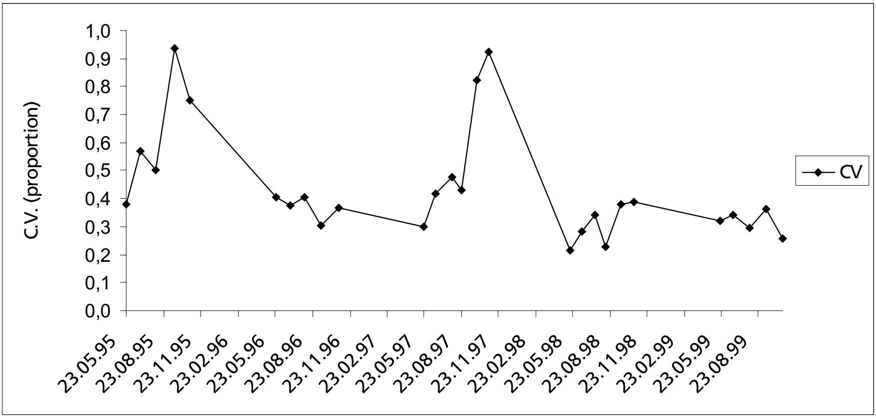
Figure 3: Statistical parameters of distribution for each grazing season (1995-1999): minimum, mean, maximum and standard deviation (SD), $(\mathrm{gDM}(2500\mathrm{cm}^2)^{-1})$



The HM standard deviation varied in 1995 from 8.2 (October) to 21.5 (June); in 1996 from 7.0 (May) to 34.4 (September); in 1997 from 14.3 (June) to 34.5 (October); in 1998 from 12.2 (May) to 36.5 (August) and in 1999 from 11.0 (May) to 58.8 (October).

The coefficient of variation (CV) is shown in Figure 4. It varied in 1995 from 0.382 (May) to 1.107 (September); in 1996 from 0.321 (September) to 0.408 (May); in 1997 from 0.259 (May) to 1.086 (October); in 1998 from 0.221 (August) to 0.411 (October) and in 1999 from 0.252 (October) to 0.415 (September).

Figure 4: Coefficient of variation (CV, proportion) for each grazing season (1995-1999).



The pre-grazing herbage mass shows spatially heterogeneous distribution, as it was indicated by the coefficient of variation in the range from 0.221 (August 1998) to 1.107 (September 1995) for all measurement dates. This heterogeneity could affect livestock production through its influence on the amount of feed available, the acceptability of that feed and its digestibility and nutrient content, each of which would show varying degrees of spatiotemporal variation (Tainton *et al.*, 1996).

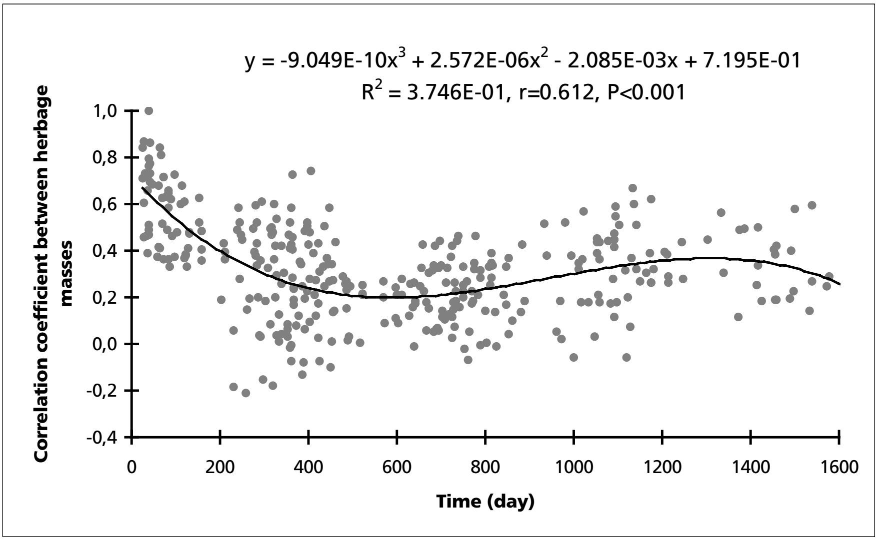
It was suggested by Edwards *et al.* (1996) that the response of plants to selective (spatially heterogeneous) grazing is a crucial factor in the development and maintenance of spatial pattern in grasslands. This is especially interesting in uniformly palatable vegetation as it was the investigated bahiagrass pasture. Experimental results on relative preferences or preference rankings reveal that herbivores show a very consistent attraction for certain plant species compared to other (Maćešić, 1995; Maćešić and Knežević, 1997; Dumont, 1997). In grasslands reach with different grass species (or grass-legume mixtures), their palatability could be the main reason for developing heterogeneity of herbage mass in a sword. But in homogeneous and palatable uniform bahiagrass pasture spatially heterogeneous grazing was the main factor, which influenced mosaic in horizontal distribution of herbage, mass. This confirms research by Bakker *et al.* (1983) who found that in also uniform *Holcus lanatus* community micro-patterns apparently developed due to random grazing.

Morris *et al.* (1999) found that structural heterogeneity was carried over to the next growing season and, with time, grazing became increasingly focussed on the short patches while tall areas were left to grow out, thereby enhancing the patch structure of the sward. The same pattern appeared to happen in bahiagrass pasture in this study. Hirata (1998) explained that the stability pattern in herbage mass is fundamentally determined by the foraging behaviour of animals and growth characteristics of plants. Therefore, grazing causes a decline in biomass but an increase in nutritive value through the stimulation of regrowth (McNaughton, 1984; Hirata, 1996).

Although the bahiagrass pasture in this experiment was rotationally grazed for five years it still maintains good stability trending to increase the herbage mass mean toward the middle of a grazing season (August/September 1996, July/August 1997, July/August 1998) or even toward the end of a grazing season (September/October 1999).

This research had also the aim to quantify the stability of sward in a long-term distribution of pre-grazing herbage mass in bahiagrass pasture, utilised under the same repeated grazing management, as it has shown in Figure 5. Each point on the graph represents correlation coefficient between two measurements dates plotted against the time differences between those dates. In previous paper HIRATA (1998) applied linear regression equation that showed that the correlation coefficient decreases as the interval between the pre-grazing measurements increases and the data sets scattered considerably around the regression line. However, that research was limited on 2.5 year available data set at that time, and it could lead to the conclusion that a negative trend in maintenance of spatial pattern of pre-grazing herbage mass is to be expected in the future. That too, can also be the example why short term experiments may give misleading results and there is the need for trials to document the long-term effect of treatments on pasture.

Figure 5: Correlation coefficient of a herbage mass on two measurements dates plotted against the time between the dates.



The correlation coefficient of multilinear regression (r=0.612) that is shown in Figure 5 is highly significant ($p < 0.001$). The multilinear regression equation shows that the correlation coefficient decreases as the interval between the pre-grazing measurements increases, reaching the lowest point after 570 days (r=0.198). After that moment, the multilinear regression curve is rising again until the peak point at 1210 days (r=0.382) from the beginning of the experiment, or 640 days after reaching the lowest point. Furthermore, the trend curve tend to decrease again reaching the lowest point in the last measurement at 1577 days (r=0.248) after the beginning of the experiment, or 367 days after the last peak. The individual data sets indicated that the spatial pattern of vegetation in bahiagrass pasture is approximately in a range of 600 days (highest point-lowest point interval). This is based on five years pre-grazing data set in bahiagrass pasture, but it is difficult to say weather this pasture is going to maintain the same spatial pattern of herbage mass in, for example, next five years. That is, to continue this research in the future is necessary task in obtaining more information about spatial heterogeneity of vegetation in bahiagrass pasture, and implication of agro ecological advantages to grazing systems.

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