バヒアグラス(Paspalum notatum Flugge)草地における草量の水平分布の牛放牧に伴う動態

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Dynamics of the Horizontal Distribution of Herbage Mass in a Bahiagrass (*Paspalum notatum* Flügge) Pasture with Grazing by Cattle

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Synopsis

HIRATA, M. and K. FUKUYAMA (1997) : Dynamics of the horizontal distribution of herbage mass in a bahiagrass (*Paspalum notatum* Flügge) pasture with grazing by cattle. *Grassland Science* 43, 1-6.

As a first step toward clarifying "How much herbage and from what herbage mass places in a pasture do grazing animals consume?", the dynamics of the horizontal distribution of herbage mass with grazing was analyzed in terms of (a) the relationship between the pre- and post-grazing herbage masses, and (b) the relationship between the change in herbage mass with grazing and the pre-grazing herbage mass. The distribution of herbage mass was measured with an electronic capacitance probe along fixed transects in a bahiagrass pasture, before and after grazing with beef cattle. It was inferred that the cattle grazed the pasture on a basic principle, with some modification of the manner in response to the mean pre-grazing herbage mass. The basic principle was that the cattle consumed more herbage from places with greater pre-grazing herbage mass to an extent that the places still maintained greater herbage mass after grazing. The modification of the manner was that the cattle selected the places with high herbage mass more strongly as the mean pre-grazing herbage mass of the pasture decreased.

Key words : Bahiagrass pasture, Grazing, Herbage mass, Horizontal distribution.

Introduction

A grazed sward is heterogeneous both in the vertical and in the horizontal plane. The heterogeneity occurs in such sward characteristics as plant biomass and botanical composition, and has considerable influences on the utilization and persistence of a grazed pasture.

Past studies on the horizontal distribution of herbage mass in a pasture have shown that the heterogeneity in herbage mass increases with grazing by animals[4,6,10,12,13]. However, the mechanisms of the increase in the heterogeneity with grazing are not fully understood. To clarify the mechanisms, a question needs to be answered : How much herbage and from what herbage mass places in a pasture do grazing animals eat?

The present study was made as a first step toward obtaining the answer to the above question. For simplicity, a highly-monocultural bahiagrass pasture was used. With an electronic capacitance probe[5], horizontal distribution of herbage mass in the pasture was measured non-destructively along fixed transects before and after grazing with beef cattle. The dynamics of the herbage mass distribution with grazing was analyzed in terms of (a) the relationship between the pre- and post-grazing herbage masses, and (b) the relationship between the change in herbage mass with grazing and the pre-grazing herbage mass.

Materials and Methods

A 1.1-ha paddock of a Pensacola bahiagrass (*Paspalum notatum* Flügge) pasture at the Sumiyoshi Livestock Farm (31°59′N, 131°28′E), Faculty of Agriculture, Miyazaki University was used for the study. The paddock was one of five paddocks (total area = 6.3 ha) rotationally grazed by Japanese Black cows and calves with supplements.

In the grazing season (May to October) of 1995, the paddock was grazed 9 times by 31 cows and 5-15 calves. The duration of each rotational grazing period was 3-5 days, and the total duration of grazing was 31 days. The everyday grazing was a daytime grazing from 9 a.m. to 4 p.m. The paddock was not mown during the grazing season. The annual fertilization rates were 81 kg N (split application in April and September), 28 kg P_2O_5 (April) and 23 kg

K_2O (April) per ha. The meteorological conditions during the grazing season are shown in Fig. 1. The rainfall from mid-July to mid-September was extremely low (79 mm, about 13% of the long-term average).

From the 9 rotational grazing periods, the first 2-day periods of 5 rotational grazing periods were selected as Periods 1 to 5. Table 1 summarizes the date, meteorological conditions, and liveweight and supplement of the cows in the 5 periods. The calves were at a rearing stage before weaning (less than 4 months old), and supplemented with concentrate (0.3-0.5 kg DM/hd/day). Field observations suggested that the calves made little contribution to the herbage consumption in the paddock (HIRATA, unpublished).

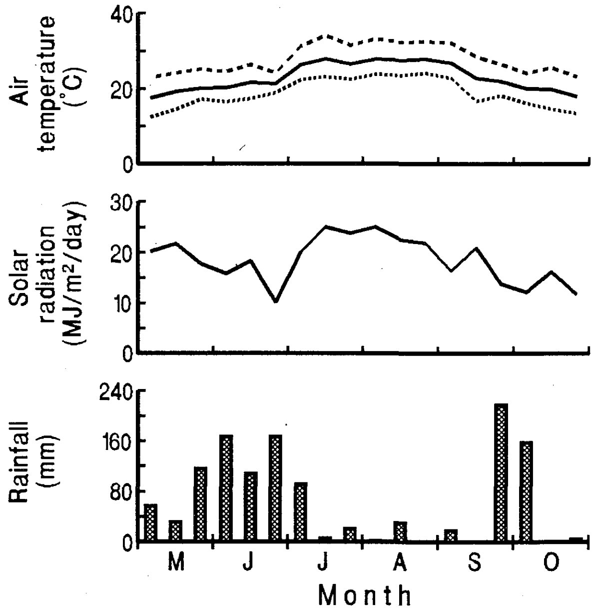

Fig. 1. Meteorological conditions during the grazing season.
Ten- or eleven-day means of maximum (----), mean (——) and minimum (······) daily air temperatures and daily total short-wave solar radiation, and ten- or eleven-day totals of rainfall are shown.

Horizontal distribution of herbage mass was measured on 10 occasions, *i.e.* immediately before and after the 5 periods. On each occasion, an electronic capacitance probe (PastureProbe™, Mosaic Systems Ltd., New Zealand) was used to measure capacitance (corrected meter reading ; CMR) at 1-m intervals along 2 fixed transects crossing the paddock. Each transect was 90 m long, and thus the CMR was determined at 182 points. For each point, the CMR was measured 3 times within an area of 50 cm × 50 cm, and the mean value was recorded as the CMR of the point. The CMR was converted into herbage mass (dry matter (DM) in an area of 50 cm × 50 cm and above a height of 3 cm) with a calibration equation which was developed on every measurement occasion.

In addition, on each pre-grazing occasion, herbage samples were taken to estimate the botanical composition of the sward. Five 50 cm × 50 cm areas whose CMR values covered the CMR range of the transects at approximately constant intervals were selected in the paddock, avoiding the vicinity of the transects. The samples cut at a height of 3 cm were divided into bahiagrass and unsown species, and oven-dried to determine the dry weight.

Table 1. Date, meteorological conditions, mean liveweight of cows and supplement offered to cows in Periods 1 to 5.

Period no.	Date	Mean air temperature (°C)[a]	Solar radiation (MJ/m^2)[b]	Rainfall (mm)[c]	Mean liveweight (kg/hd)[d]	Supplement offered (kg DM/hd/day)[e]
1	24 May	24.6	19.6	0.0	429.9	2.0 (RH)
	25 May	20.4	2.0	5.5	429.5	2.0 (RH)
2	28 June	22.7	7.7	0.0	449.7	1.7 (RH)
	29 June	26.0	21.7	0.0	450.9	1.7 (RH)
3	5 Aug.	31.8	19.9	0.0	467.2	2.2 (RH)
	6 Aug.	31.1	18.6	0.0	466.9	2.2 (RH)
4	20 Sep.	23.6	12.1	0.0	444.6	3.4 (CS)
	21 Sep.	25.7	16.7	0.0	443.8	3.1 (CS)
5	28 Oct.	19.0	2.6	1.0	441.6	–
	29 Oct.	22.8	10.8	0.0	443.3	–

[a] Mean value over a daytime grazing period (9 a.m. to 4 p.m.).
[b] Total short-wave solar radiation. Total value over a daytime grazing period.
[c] Total value over a daytime grazing period.
[d] Estimated value from measurements at intervals of 28-49 days. The number of cows was 31.
[e] Calculated by dividing the total amount of supplement offered in the previous evening by the number of cows. The supplement was Rhodesgrass hay (RH) or corn silage (CS). – indicates no supplementary feeding.

Results and Discussion

Figure 2 shows the pre- and post-grazing distributions of herbage mass along the transects in Periods 1 to 5. Bahiagrass accounted for 87.2, 97.0, 99.6, 96.9 and 96.7% of the pre-grazing herbage mass (dry matter basis) in Periods 1, 2, 3, 4 and 5, respectively. Reflecting the extremely low rainfall between mid-July and mid-September (Fig. 1), the pre-grazing herbage mass in Periods 3 and 4 was lower than that in the normal years. The herbage allowance which was calculated from the mean pre-grazing herbage mass, paddock size and mean liveweight and number of cows (Table 1) was 145.5, 106.6, 84.3, 31.6 and 37.0 g DM/kg LW for Periods 1, 2, 3, 4 and 5, respectively, and was highly correlated with the mean pre-grazing herbage mass ($r=0.998, P<0.001$). With the grazing, the horizontal heterogeneity in herbage mass increased, as indicated by the rise in the coefficient of variation. Thus, the present study confirmed the previous findings[4,6,10,12,13].

To understand the mechanisms of such an increase in the heterogeneity in herbage mass with grazing, it is necessary to clarify how much herbage and from what herbage mass places in a pasture grazing animals consume. As a first step toward this, the

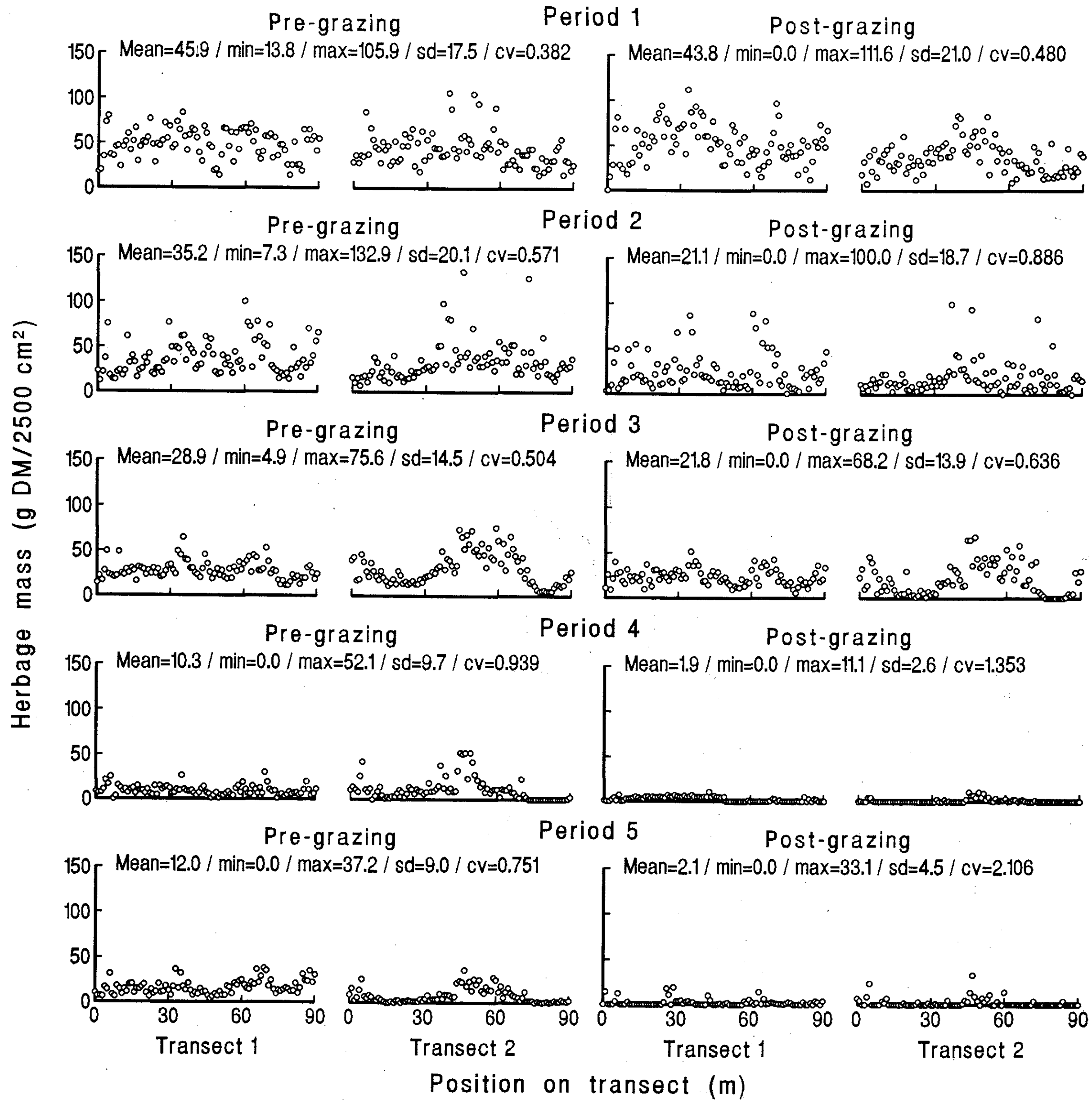

Fig. 2. Pre- and post-grazing distributions of herbage mass along the transects.
The mean (g DM/2500 cm^2), minimum (min, g DM/2500 cm^2), maximum (max, g DM/2500 cm^2), standard deviation (sd, g DM/2500 cm^2) and coefficient of variation (cv, fraction) are shown as statistics. For Periods 1 to 5, refer to Table 1 and text.

present study analyzed the dynamics of the herbage mass distribution in the following two aspects.

First, the relationship between the pre- and post-grazing herbage masses along the transects was examined (Fig. 3). The post-grazing herbage mass was always positively correlated with the pre-grazing herbage mass. This fact indicates that the cattle grazed the pasture in such a manner that the places with greater herbage mass before grazing still kept greater herbage mass after grazing. Results that imply a similar phenomenon have been obtained in a bahiagrass pasture grazed by beef heifers and steers[10].

Second, the relationship between the change in herbage mass with grazing and the pre-grazing herbage mass along the transects was investigated (Fig. 4). The change in herbage mass with grazing was calculated as the post-grazing herbage mass minus the pre-grazing herbage mass, which equals the balance between herbage growth and consumption during the period. Here, for Periods 3 and 4, because of the severe drought, herbage growth during the periods may be regarded nil. There were always negative correlations between the change in herbage mass with grazing and the pre-grazing herbage mass. This fact suggests that the cattle grazed the pasture in a manner that they consumed more herbage from places which had greater herbage mass before grazing.

At the same time, in Fig. 4, there were some differences between the 5 periods in the scattering pattern of data. In Period 1, when the mean pre-grazing herbage mass over the transects was relatively large (Fig. 2), the change in herbage mass with grazing was in a wide range between negative and positive. By contrast, in Periods 4 and 5, when the mean pre-grazing herbage mass was small (Fig. 2), the change in herbage mass with grazing almost always showed negative values. In addition, the correlation between the change in herbage mass with grazing and the pre-grazing herbage mass (r in Fig. 4) became stronger as the mean pre-grazing herbage mass over the transects decreased (Fig. 5). These facts suggest the following : When the mean pre-grazing herbage mass was relatively high, the cattle grazed some places in the pasture intensively but left some places almost ungrazed. The amount of herbage consumed from each place was comparatively unrelated to the pre-grazing herbage mass of the place. On the contrary, when the mean pre-grazing herbage

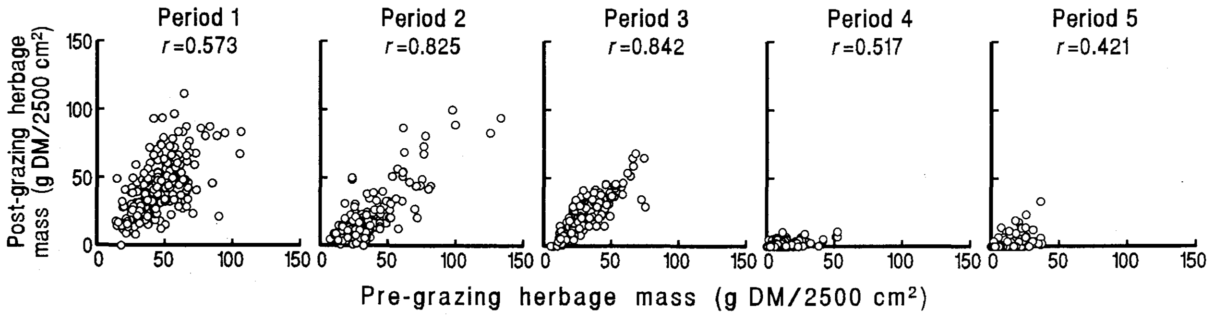

Fig. 3. Relationships between the pre- and post-grazing herbage masses along the transects.
All the correlation coefficients (r) are significant at 0.1% level ($n=182$). For Periods 1 to 5, refer to Table 1 and text.

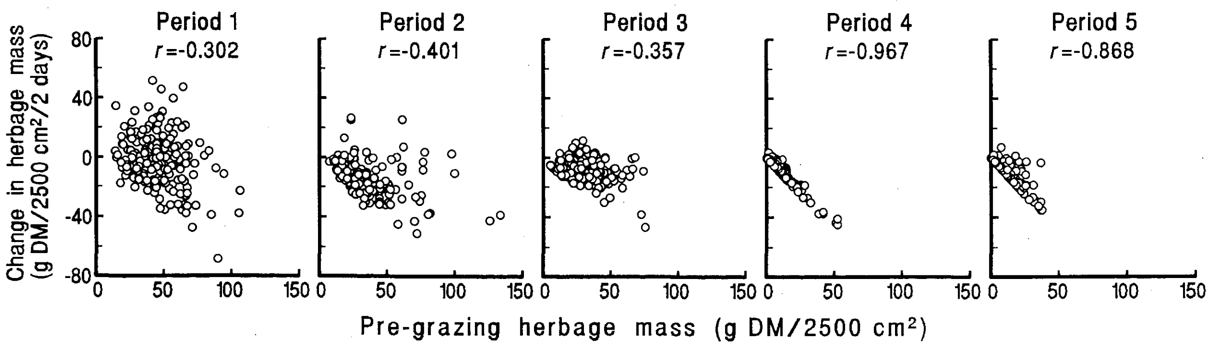

Fig. 4. Relationships between the change in herbage mass with grazing and the pre-grazing herbage mass along the transects.
All the correlation coefficients (r) are significant at 0.1% level ($n=182$). For Periods 1 to 5, refer to Table 1 and text.

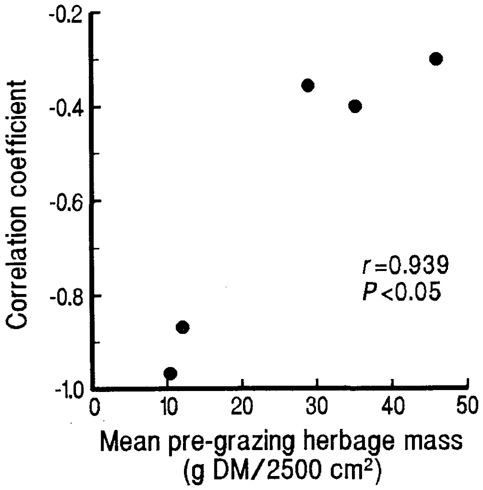

Fig. 5. Effect of the mean pre-grazing herbage mass over the transects on the correlation coefficient between the change in herbage mass with grazing and the pre-grazing herbage mass along the transects.
The correlation coefficients derive from Fig. 4.

mass was low, the cattle grazed almost all the places in the pasture, and the amount of herbage consumed from each place was comparatively proportional to the pre-grazing herbage mass of the place. Thus, the selection by the cattle for the feeding places in the pasture changed with the mean pre-grazing herbage mass of the pasture. The herbage mass or the availability of herbage in the respective places became more important in the selection as the mean pre-grazing herbage mass decreased.

From the above results, it is inferred that the cattle grazed the pasture on a basic principle, with some modification of the manner in response to the mean pre-grazing herbage mass. The basic principle, as derived from the general correlation trends in Figs. 3 and 4, is that the cattle consumed more herbage from places with greater pre-grazing herbage mass to an extent that the places still maintained greater herbage mass after grazing. The modification of the manner, as suggested by the scattering pattern of data in Fig. 4 and by Fig. 5, is that the cattle more strongly selected the places with large herbage mass as the mean pre-grazing herbage mass of the pasture decreased.

An example of such modification of the animals' selectivity was obtained from field observations on the herbage consumption from places around dung pats (HIRATA, unpublished). When the mean pre-grazing herbage mass of the pasture was relatively high (*e.g.* Period 1), the cattle consumed little herbage from places around dung pats, even though the places had greater herbage mass than the dung-free places. However, when the mean pre-grazing herbage mass was low (*e.g.* Periods 4 and 5), the cattle consumed considerable amount of herbage from places around dung pats which had greater herbage mass than the dung-free places. Although these phenomena have been empirically well known, few quantitative analyses have been made[3]. The data from the present study is useful for such analyses.

In Period 1, the change in herbage mass with grazing was as high as over 10 g DM/2500 cm^2/2 days in many places of the pasture (Fig. 4). These values are much higher than those attained by the herbage growth[7]. Therefore, the estimated herbage masses in this period are considered to involve considerable errors. However, the inference from the present study is still valid, because exclusion of the data set of Period 1 from Fig. 5 also resulted in a significant correlation ($r=0.962$, $P<0.05$).

Previous studies have generally described the sward characteristics of a grazed pasture such as herbage mass and botanical composition as an average over the pasture. Similarly, herbage consumption and its botanical composition have been described as an average. These descriptions, however, do not reflect the real conditions of a pasture, and give us only limited information on what is happening in a pasture. Recently, studies on the horizontal distribution of herbage mass have deepened our understanding of the heterogeneity in herbage mass in a grazed pasture[4,6,10-13]. By contrast, our knowledge on the heterogeneity in herbage consumption is still very limited. In this respect, the present study has afforded new, valuable information on the heterogeneity in herbage consumption in a grazed pasture dominated by a tropical grass species. The information can also be a starting point for analyzing herbage consumption in a multi-species pasture.

In future measurements and analyses with the present technique, the following need to be taken into account : (a) measurements in a wider range of mean pre-grazing herbage mass for obtaining more general information, (b) estimation of herbage growth during a grazing period for accurately estimating herbage consumption, and (c) more frequent measurements during a grazing period (*e.g.* at 1-day intervals) for clarifying the sequence of herbage consumption within a grazing period. In addition, it will be important to combine the technique with measurements of ingestive behaviors of animals. Several studies have been made to investigate patch selection of animals in terms of ingestive behaviors[1,2,8,9], and this approach has been proved to be useful in understanding the heterogeneous herbage consumption by animals grazing patchy swards. Therefore, the final answer to the question, "How much herbage and from what herbage mass places in a pasture do grazing animals eat?", can be obtained from such integrated studies.

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要　　旨

平田昌彦・福山喜一* (1997)：バヒアグラス (*Paspalum notatum* Flügge) 草地における草量の水平分布の牛放牧に伴う動態. *Grassland Science* **43**, 1-6. 宮崎大学農学部草地畜産学講座 (889-21 宮崎市学園木花台西 1-1) *宮崎大学農学部附属農場住吉牧場 (880-01 宮崎市大字島之内 10100-1)

放牧家畜が草地のどのような草量の場所からどれだけ採食するのかを解明する第1歩として，草量の水平分布の放牧に伴う動態を，放牧前後の草量の関係，ならびに，放牧に伴う草量変化と放牧前草量との関係，といった点から解析した。草量の水平分布は，草量計を用いて，肉牛が放牧されるバヒアグラス草地において，放牧前後に，固定トランセクトに沿って測定した。牛群は，放牧前草量の大きな場所から，そこの草量が放牧後にも大きく維持される程度に，多く採食するという基本原則に従い，かつ，放牧前の平均草量が小さいほど，草量の大きな場所をより強く選択する傾向で，草地を採食したと考えられた。

キーワード：水平分布，草量，バヒアグラス放牧草地，放牧.