Quantification of Cattle Dung-Related Processes in Bahiagrass Pasture

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Introduction

Dung deposition by grazing cattle is a peculiar phenomenon to the grazed pasture. Therefore, as reviewed by Marsh and Campling[5], a number of studies have been made on the cattle dung-related processes in the pasture such as distribution of dung, decomposition of dung, and effects of dung on herbage yield and consumption. However, it is still a question how the cattle dung affects the whole pasture productivity. This is primarily due to the incompleteness of the quantitative information on the above dung-related processes. Accumulation of the quantitative data is needed to evaluate the cattle dung effect on the pasture productivity.

Bahiagrass (*Paspalum notatum* Flügge) is one of the most common pasture species in the southwestern warm region of Japan. The question of the cattle dung effect also arises in bahiagrass pasture. Authors therefore conducted the investigation of bahiagrass productivity paying a considerable attention to the cattle dung. This paper briefly presents the quantification of the cattle dung-related processes derived from the results of our investigation.

Return of dung to pasture

Bahiagrass pasture (45 m × 39 m) was grazed eight times by 21–24 Holstein heifers under a rotational system. A resting place (5 m × 12 m) was attached to the pasture from the grazing no. 4 onward. The detailed pasture and grazing conditions were already published[3]. Some characteristics of the return of dung are given in Table 1.

Table 1. Some characteristics of the return of dung to pasture[a)]

Grazing no.	Dung dry weight excreted (g DW/head/day)	Number of defecations (no./head/day)	Number of dung pats (no./head/day)	Number of dung pats per defecation
1	2318	—[b)]	13. 36	—
2	—	—	10. 73	—
3	673	—	8. 27	—
4	—	6. 50	11. 08	1. 71
5	1398	6. 54	10. 29	1. 57
6	—	6. 96	12. 43	1. 79
7	2051	8. 24	12. 19	1. 48
8	3298	7. 74	13. 57	1. 75

a) : Pasture with a resting place from the grazing no. 4 onward.
b) : Measurement was not done where horizontal bars are present.

1) *Dung dry weight*

Daily excretion of dung dry weight (*DED*) ranged from 673 to 3298 g DW/head/day, and was linearly and positively related to the daily dry matter intake of herbage and concentrate (*IHC*, g DW/head/day):

$$DED = 73.80 + 0.3627 IHC$$
$$(r^2 = 0.861,\ P < 0.05).$$

2) *Number of defecations*

Daily number of defecations (*DND*) took the values of 6.50 to 8.24 per head per day, and was also related to *IHC*:

$$DND = 5.91 + 0.000274 IHC$$
$$(r^2 = 0.750,\ P < 0.10).$$

3) *Number of dung pats*

Daily number of dung pats ranged from 8.27 to 13.57 per head per day. Number of dung pats exceeded that of defecations, since the cattle sometimes defecated while moving. Number of dung pats per defecation was in the range of 1.48 to 1.79, and was relatively constant over the five grazings.

Dispersion of dung pats in pasture

Dispersion of dung pats was examined in relation to grazing equipments in the pasture described in the previous section. The pasture was first divided into thirty 7.5 m × 7.8 m large rectangles. In case of the grazing nos. 4 to 8, the resting place was regarded as one of the large rectangles. Arrangement of the grazing equipments and the large rectangles is illustrated in Fig. 1 with the numbers of dung pats. The proportion of dung pats (*PDP*) in each rectangle to total pats was calculated. The distances between the center of each rectangle and the grazing equipments were also calculated. For the grazing nos. 1 to 3 without the resting place, *PDP* was expressed as follows:

$$PDP = 0.5002 DCT^{-0.4235} DGT^{-0.4208}$$
$$(r^2 = 0.583,\ P < 0.001),$$

where *DCT* and *DGT* are the distances (m) from the concentrate-feeding troughs and

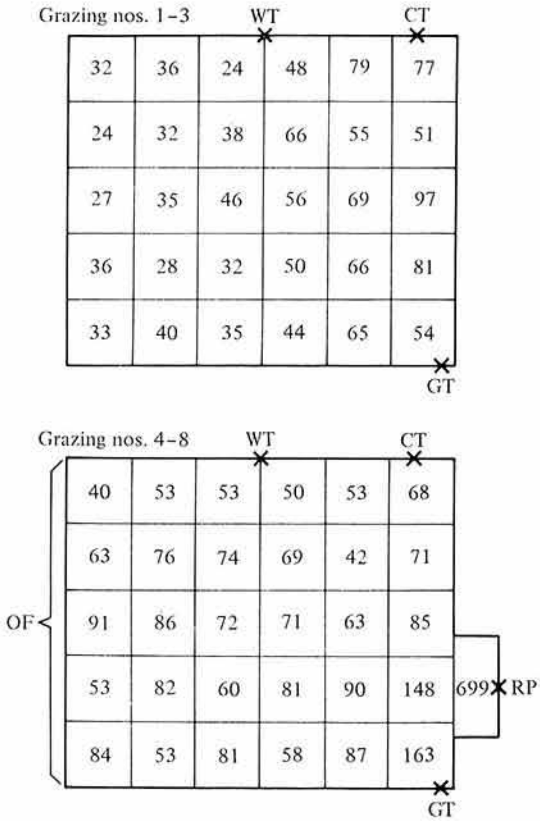

Fig. 1. Arrangement of grazing equipments and large rectangles at the grazing nos. 1–3 (above) and the grazing nos. 4–8 (below)
Grazing equipments are water troughs (WT), concentrate-feeding troughs (CT), gate (GT), resting place (RP) and opposite fence-line to the resting place (OF). For the large rectangles, see the text. Figures in the rectangles denote the numbers of dung pats cumulated for the two groups of grazing nos.

from the gate, respectively. Following equation was obtained for the grazing nos. 4 to 8 with the resting place:

$$PDP = 1.6421 DRP^{-0.9699} DOF^{-0.3408}$$
$$(r^2 = 0.964,\ P < 0.001),$$

where *DRP* and *DOF* are the distances (m) from the resting place and from the opposite fence-line to the resting place, respectively.

Then, the dispersion of dung pats in each large rectangle of the pasture was examined. Each rectangle was further divided into twenty-five 1.50 m × 1.56 m small rectangles, and the numbers of dung pats in the small rectangles were counted. Chi-square test for goodness of fit showed that the dispersion of dung pats in the large rectangles was mostly well described by the Poisson distribution.

Disappearance of dung

Three kinds of 1 m × 1 m swards were established in a bahiagrass pasture (15 m × 39 m) rotationally grazed by 18–25 Holstein heifers; ND (no dung deposition), JD (an artificial dung deposition on 1 June) and AD (an artificial dung deposition on 28 August) swards. The overlooked view of JD and AD swards is illustrated in Fig. 2. The experimental condition and procedure were already presented in detail[4]. Dung pat in JD sward disappeared faster than that in AD sward as shown in Fig. 3. The rate of dung disappearance (*RDD*, g DW/g DW/day) was linearly and positively related to the daily precipitation (*PRC*, mm/day):

$$RDD = 0.00549 + 0.00573PRC \quad (r^2 = 0.959,\ P < 0.05).$$

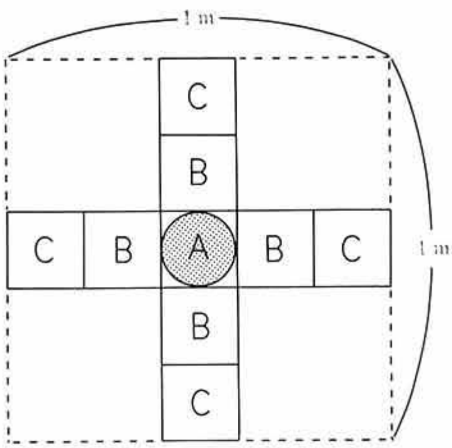

Fig. 2. Overlooked view of JD and AD swards
Shaded part in A is the position where a dung pat was deposited.
Sward samples were taken from the places of A, B and C.
Distances from the dung are 0–10 cm(A), 10–30 cm(B) and 30–50 cm(C).

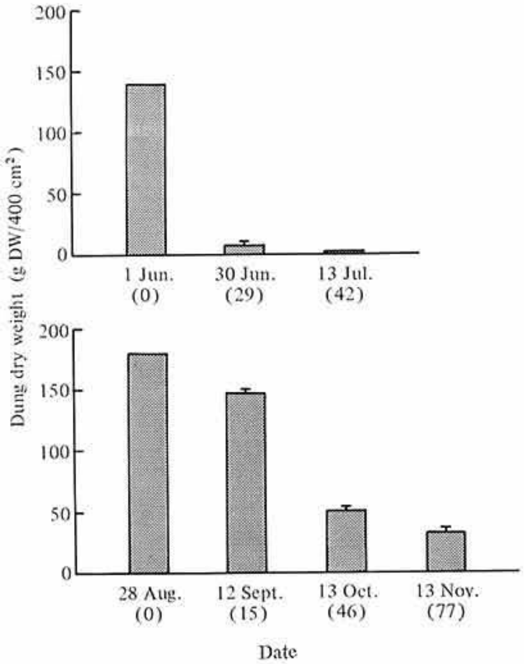

Fig. 3. Dung dry weight in JD (above) and AD (below) swards
Figures in parentheses show days after the dung deposition.
Vertical bars denote SE of the mean.

If we use a multiple regression in spite of the small number of samples, *RDD* was given by the equation:

$$RDD = 0.04522 + 0.00631PRC - 0.00239MAT \quad (r^2 = 0.999,\ P < 0.05),$$

where *MAT* is the daily mean air temperature (°C).

Effect of dung on herbage consumption

Cattle dung effect on herbage consumption was investigated in the above-mentioned ND, JD and AD swards (Fig. 2). Consumed herbage dry weight in the three places of JD and AD swards is compared with that in ND sward in Fig. 4. Consumed herbage is expressed on the bases of the sward sampling area (400 cm²) and the cattle live weight (mean live weight × cattle number, kg LW).

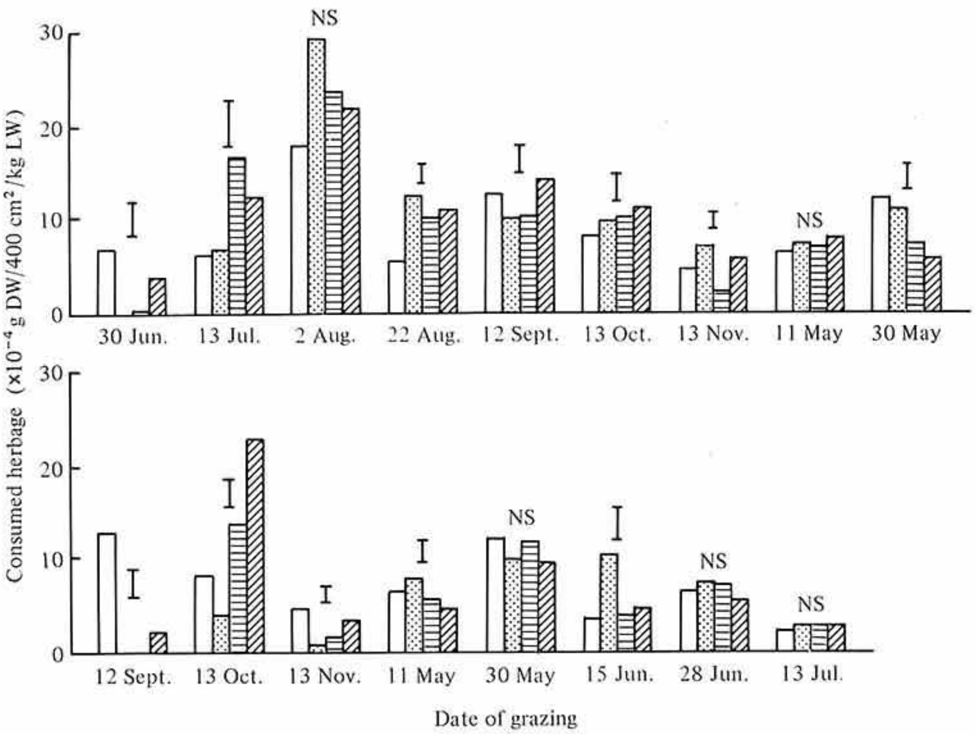

Fig. 4. Consumed herbage dry weight in JD (above) and AD (below) swards as compared with that in ND sward

□ : ND sward,

▨ : 0∼10 cm place in JD and AD swards,

▤ : 10∼30 cm place in JD and AD swards,

▨ : 30∼50cm place in JD and AD swards.

Vertical bars denote LSD at 5% level.

Consumed herbage dry weight (CHW, $\times 10^{-4}$ g DW/400 cm^2/kg LW) in ND sward, the dung-free place, was linearly and positively related to the before-grazing herbage dry weight (BHW, $\times 10^{-4}$ g DW/400 cm^2/kg LW, above the ground level):

$$CHW = -3.606 + 0.305BHW \quad (r^2 = 0.369,\ P < 0.05).$$

Accordingly, CHW in the dung-deposited and surrounding places (three places in JD and AD swards) can be described as follows:

$$CHW = RDF(-3.606 + 0.305BHW),$$

where RDF is the ratio of CHW in the dung-deposited and surrounding places to that in the dung-free place. Here, using the data at the grazings in which the dung pats still remained (Figs. 3 and 4), RDF was expressed by the following equation:

$$RDF = e^{(-0.0447+0.0008DST)DPW} \quad (r^2 = 0.232,\ P < 0.25),$$

where DST is the distance (cm) from the dung pat (5, 20 and 40 cm for the 0–10 cm, 10–30 cm and 30–50 cm places, respectively) and DPW is the dung pat weight (g DW/400 cm^2) in 0–10 cm place. Although the regression to RDF is not significant, these equational descriptions are important because of the unavailability of the quantified data on the dung-affected herbage consumption.

Effect of dung on herbage growth

Cattle dung effect on herbage growth was examined in the same ND, JD and AD swards as before (Fig. 2). Herbage growth rate in the three places of JD and AD swards is compared with that in ND sward in Fig. 5. Herbage growth rate was expressed as the daily increment of herbage dry weight (above the ground level) per 400 cm^2.

1) Stimulative effect

Dung is considered to promote the herbage growth by the increment of leaf area index (LAI) due to the reduced herbage consump-

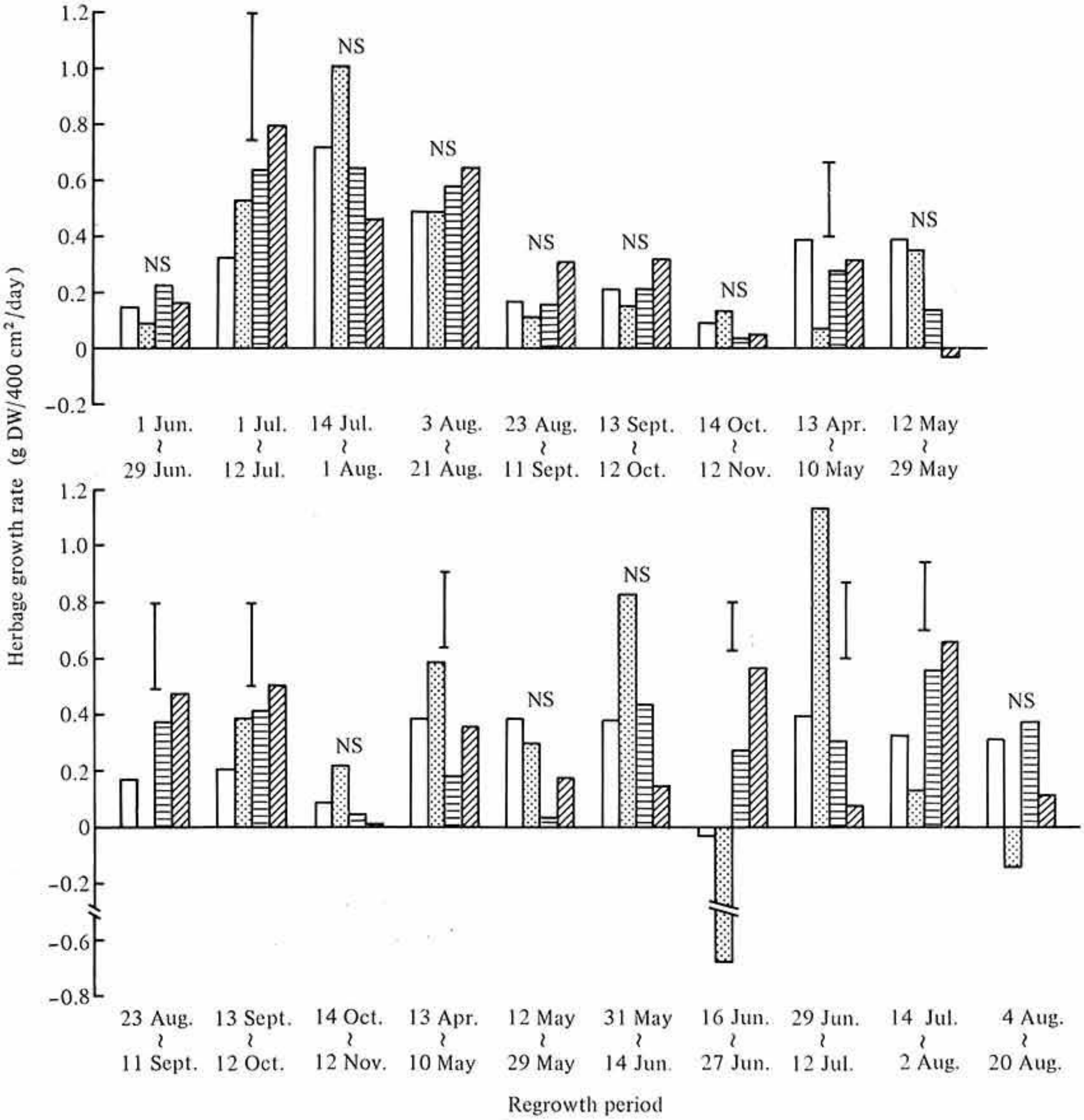

Fig. 5. Herbage growth rate in JD (above) and AD (below) swards as compared with that in ND sward
Symbols are the same as in Fig. 4.
Vertical bars denote LSD at 5% level.

tion and by the addition of dung-derived nutrient. Here, we regard the leaf nitrogen percent as an indicator of the dung-derived nutrient. In most cases where the herbage growth rate in JD and/or AD swards differed significantly from that in ND sward (Fig. 5), the LAI was more strongly correlated to the herbage growth than the leaf nitrogen percent. Therefore, the LAI is an indispensable factor to the expression of the herbage growth rate in order to realize the stimulative effect of dung. For example, according to our studies so far, herbage growth rate (*HGR*, g DW/400 cm²/day) in bahiagrass pasture is formulated as follows:

$$HGR = -0.2783 + (0.1635 + 0.1370\,TSSR)\,LAI - 0.0256\,LAI^2$$
$$(r^2 = 0.543,\ P < 0.001),$$

where *TSSR* is the daily total short-wave solar radiation (MJ/400 cm²/day) and *LAI* is the leaf area index.

2) Retardative effect

It is known that the herbage covered by the dung pat is killed resulting in the reduction of herbage growth. Therefore the relation of *HGR* to dung pat weight (*DPW*, g DW/400 cm²) was examined in 0–10 cm place using the data for the regrowth periods where the dung pats still remained (Figs. 3 and 5):

$$HGR = 0.3852 - 0.0021\,DPW$$
$$(r^2 = 0.365,\ P < 0.30).$$

This equation, though insignificant, is also important because of the lack of available data.

Synthesis of quantitative data

Quantification of the cattle dung-related processes is important to evaluate the dung effect on the pasture productivity. At the same time, synthesis of the quantified data is more important to the evaluation because of the entanglement of the processes. Simulation study using a mathematical model is effective on this occasion. Some researchers[1,2] in fact have made simulation trials to evaluate the dung effect. These trials, however, indicated further need for the quantified data on such processes as the dung effects on herbage consumption and growth. Authors intend to attempt a simulation study using the data in the present paper.

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