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# Ingestive behavior and short-term intake rate of cattle grazing on tall grasses

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ABSTRACT

Tall grasses ( > 1 m tall) are an important forage resource for grazing ruminants. Understanding the ingestive behavior and short-term intake rate of cattle grazing on tall grasses will help facilitate grazing management of tall grass pastures. The aim of this study was to determine the allocation of jaw movements in grazing cattle in relation to tall grasses and to assess whether such allocations of jaw movements are effective for maintaining a short-term intake rate. Four plants were used as test plants: bahiagrass (*Paspalum notatum* Flügge; a short grass), Sudangrass (*Sorghum* × *drummondii*; a typical tall grass) and two growth forms of a dwarf bamboo (*Sasa senanensis*; a semi-woody form of tall grass): a naturally growing form (NGDB, approximately 2 m tall) and a form that is under grazing (DBUG, < 0.8 m). Four Japanese Black cows were allowed to graze each plant in random order. The grazing jaw movements and intake rate were measured using an integrated method with a microsward technique and acoustic monitoring. The cows performed the highest number of total bites (simple bites+chew-bites) for bahiagrass, an intermediate number of total bites for Sudangrass and DBUG and the lowest number of total bites for NGDB ($P < 0.05$). The total number of chews (simple chews+chew-bites) was similar among NGDB, DBUG, and Sudangrass, whereas the total number of chews for bahiagrass was less than that for dwarf bamboos. The number of observed chew-bites exhibited an order similar to that observed for the number of total bites. As a result of each jaw movement, cows ingesting the DBUG moved their jaws more frequently among the plants, and cows ingesting the bahiagrass performed the fewest grazing jaw movements. Bite mass was considerably greater in the cows ingesting NGDB than in the cows ingesting other plants. Conversely, the chew mass for bahiagrass was clearly greater than that for the two taller plants. Cows ingesting Sudangrass processed the least amount of forage with each chew ($P < 0.05$). The intake rate did not significantly differ among the plants ($P > 0.05$), except for Sudangrass. Cows ingested Sudangrass at a lower intake rate than observed for the other plants ($P < 0.05$). The results suggest that cattle were able to control their ingestive jaw movements depending on plant characteristics such as height, the spatial arrangement of the leaves and leaf morphology. However, the lower short-term intake rate for tall grasses implies that there is a limit to the adaptability of grazing jaw movements.



## 1. Introduction

Tall grasses that grow more than 1 m tall are an important forage resource for grazing ruminants in some regions of the world. For example, elephant grass (*Pennisetum purpureum* Sehumach), which is a cane-like grass with thick and strong stems (Aroeira et al., 2001), and forage sorghum (*Sorghum bicolor*), including hybrid varieties (Collett, 2004), are used for cattle grazing in tropical and subtropical regions. *Miscanthus sinensis* Anders, which is a native, fully erect, cespitose, warm-season perennial grass, has been used as a forage resource in semi-natural grasslands and forest grazing in the cool-temperate to warm-temperate regions of Japan (Hayashi et al., 1968; Hirata et al., 2007).

Tall grasses are considerably different from short and dense grasses in terms of canopy structure characteristics such as height, density, leaf-to-stem proportion and spatial leaf arrangement. These structural characteristics can affect the herbage intake of grazing animals. Herbage intake is an essential factor for the production and survival of grazing animals, even when they encounter various vegetational environments. Although various factors affect the herbage intake of grazing animals, the rate of herbage intake is a key determinant of daily herbage intake. Intake rate is the consequence of grazing jaw movements, which consist of prehending (biting) and processing (chewing) jaw movements (Ungar, 1996). However, the ingestive behavior of grazing animals

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has been more intensively studied with short and dense grass species (e.g., Laca et al., 1994; Ungar et al., 2006; Galli et al., 2011), and little information is available on the ingestive behaviors of animals grazing tall grasses (Hirata et al., 2011). Thus, addressing the ingestive behavior of cattle grazing on tall grasses and the intake rate resulting from such ingestive behavior will help facilitate the grazing management of tall grass pastures.

Among tall grasses, plant structure and morphology, which include size, the spatial arrangement of the leaves and leaf bulk density, vary (Sollenberger and Burns, 2001; Hirata et al., 2011). Different plant forms necessitate different motor patterns for their harvest (Flores et al., 1989). Herbivores exhibit a variety of prehension patterns and head orientations associated with harvesting forage (Flores et al., 1989; Agreil and Meuret, 2004; Bonnet et al., 2011). Hirata et al. (2011) observed the foraging behaviors of cattle grazing on tall grass and suggested that cattle have the ability to forage tall grass efficiently by controlling the allotment of jaw movements among the leaves on the stem and among the positions of the individual leaves (Hirata et al., 2011). However, the authors did not measure the allocation of cattle jaw movements, which are composed of simple bites, simple chews and chew-bites. If cattle have the ability to forage tall grasses efficiently, they can control the allocation of these jaw movements and maintain their intake rate on tall grasses as well as maintain it on short grasses.

In the present study, we used Sudangrass (*Sorghum* × *drummondii*), which is a species in the genus *Sorghum*, as a typical tall grass and a dwarf bamboo (*Sasa senanensis*) as a differently shaped tall grass. Dwarf bamboo refers to a group of native grasses that are used for grazing in Japan (Nakano et al., 2015). These plants are generally semi-woody, with stiff and fibrous culms and leaves, and are markedly reduced in size under heavy grazing (Hirayoshi et al., 1969b). We considered the unique form and characteristics of this plant to be appropriate for use in testing how the ingestive behaviors of grazing cattle correspond to the various plant structures.

The aims of this study were to determine (1) how cattle allocate their grazing jaw movements in relation to plant form, with an emphasis on tall grasses, and (2) whether such allocations of grazing jaw movements are effective for increasing or maintaining a short-term intake rate.

## 2. Materials and methods

This study was conducted at the Minokamo Livestock Farm, Gifu Field Science Center, Gifu University, Japan (35°18′N, 137°00′E). All animal experimental procedures were approved by the Committee for Animal Research and Welfare of Gifu University (#2009-09123).

### 2.1. Plant material

#### 2.1.1. Bahiagrass

Bahiagrass grown in nursery boxes was used for the experiment. A total of 168 nursery boxes (320 mm × 250 mm × 75 mm, with 2-mm mesh drainage holes) were filled with commercial culture soil. Approximately 10 g of bahiagrass seeds was sown and grown in each box. All boxes were left in a sunny field and were watered regularly after germination. The grasses were cultivated for approximately one month and were used in the experiment when the grass height reached approximately 40 cm. The tops of the boxes were covered tightly with plastic nets after sowing to prevent the tillers from being pulled out when cattle grazed the grown grasses.

#### 2.1.2. Sudangrass

Sudangrass was used as an example of a typical tall grass species. Before sowing, a small field (15 m × 10 m) on the farm was plowed. Sudangrass seeds were sown at the rate commercially recommended for soilage (3 kg/10 a) and grown in the field for over one month. Just before each grazing session, the plants that were approximately 140 cm in height were harvested and fixed to an aluminum pipe on the microsward as described below.

#### 2.1.3. S. senanensis

*S. senanensis* plants were harvested from a naturally growing population on a foothill of Mount Ontake (35°99′N, 137°34′E; 1230 m asl), Gifu Prefecture, located in central Japan. Generally, *S. senanensis* is grown to approximately 200 cm height. Under grazing conditions, however, the plant remains between 40 cm and 100 cm in height (Hirayoshi et al., 1969a, 1969b). On the day before each grazing session, approximately 800 culms of fully developed *S. senanensis* were harvested as close to the ground as possible with a pair of pruning shears. Approximately half of the harvested plants were left as whole plants (NGDB: 180–200 cm height) and used for the grazing session, whereas the remaining plants were shortened by cutting the culm from the base (DBUG; 60–80 cm height) to simulate dwarf bamboo under heavy grazing conditions. A rough separation of undesirable tillers and dead tissue was performed at the harvesting site. These harvested plants were transported immediately in a truck to the experimental site. After arriving at the experimental site, the harvested plants were placed in buckets filled with water and kept in cool storage, allowing them to avoid direct sunlight until the grazing session. Just before each grazing session, the microsward was prepared by fixing either NGDB or DBUG to an aluminum pipe.

### 2.2. Microsward

Two types of microswards were prepared according to methods described in earlier studies (Black and Kenney 1984; Laca et al., 1992) to simulate natural vegetation; one methodology is for *S. senanensis* and Sudangrass, and the other is for bahiagrass.

#### 2.2.1. Bahiagrass

Microswards on trays (Orr et al., 2005; Soder et al., 2009) were prepared for bahiagrass. Nine empty nursery boxes (the same boxes used for grass cultivation) were placed in a 3 × 3 arrangement and attached to a wooden board ( 1000 mm × 840 mm, 10 mm thick) with screws. The baseboard was a commercial plastic pallet (1100 mm × 1100 mm × 120 mm, weighing 9.5 kg) in which an opening ( 1000 mm × 840 mm × 100 mm) was made. The boxes were attached to a wooden board set in the opening of the baseboard and affixed with brackets. The grass boxes were laid on the nine empty boxes, fixed tightly with brackets, and used for the experiment (Fig. 1a). The weight of each microsward was approximately 25 kg; thus, lifting of the microsward during grazing was not observed.

#### 2.2.2. S. senanensis and Sudangrass

A baseboard with an opening ( 1000 mm × ;1000 mm × 100 mm) similar to the one used for the bahiagrass was prepared. Four removal modules (500 mm × 500 mm × 120 mm/module) were attached to the opening of the baseboard. A composite board (500 mm × 500 mm × 5 mm), which had 18 mm holes in a 5 × 5 alignment that were 83 mm apart, was screwed to the top of each module. An aluminum pipe (150 mm across, 1000 mm long) was inserted into each hole, and the lower end was attached to a polyethylene tube with a hose clamp. A culm of *S. senanensis* or Sudangrass was introduced into the pipe and tightened by the clump to prevent the plant from being pulled out when cattle