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Intake and digestibility by sheep of different growth stages of reed canary-grass (*Phalaris arundinacea* L.)

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ABSTRACT

We investigated the intake and digestibility of different reed canary-grass (RCG) growth stages by sheep. RCG was cultivated in an experimental field and harvested at the first and second cuts at each pre-blooming stage. Feeding behavior was observed on adult female sheep, fed 3 kg each of fresh RCG three times daily. Although the crude protein content and dry matter digestibility of RCG were significantly higher in leaf than in stem tissue at both harvesting times, both neutral and acid detergent fiber contents were higher in stem than in leaf. The dry matter intake of RCG at the second cut (296.1g) was significantly higher than at the first cut. The eating time for consumption of dry matter at the second cut (54.9 min) was shorter than at the first cut. Consequently, at the second cut, the rate of biting (54.6 bites/min) was lower than at the first cut. Bite size, expressed as dry matter intake per bite, ranged from 0.05 g at first cut to 0.10 g at second cut.

Key words:
Bite size, Chemical composition, Digestibility, Feeding behavior, Reed canary-grass.

INTRODUCTION

Reed canary-grass (*Phalaris arundinacea* L.) (RCG) is cultivated in many European countries and other temperate regions in the northern hemisphere as a domestic ruminant feed [1]. In Japan, the growth characteristics and nutritional value of RCG have been studied through practical cultivation in the field and measurement of its chemical composition and digestibility [2]. The dry matter yield of the first crop increases rapidly at the heading stage, particularly in the stems. The dry matter yield of the second crop increases linearly with the growth of the plant but the main increase is in the leaves, and the stems contribute a maximum of 30% of the total. The crude protein and digestible dry matter contents at the pre-heading (pre-blooming) stage are higher than at the heading stage.

As the voluntary consumption of forage by ruminants reflects the digestibility and chemical composition of plants, the intake of early-stage (pre-blooming) grasses is higher than that of post-blooming grasses. This is because the contents of soluble carbohydrates and undegradable fibers are higher before maturation, after which lignification of plant structures occurs, depressing digestibility and intake [3].

Compared with studies of other temperate grasses, such as timothy grass, orchard grass, and Italian ryegrass, less is known about RCG as a feed for ruminant production. Basic RCG nutritional information is a fundamental prerequisite to understand the proper use of this grass for promoting livestock production and improving its nutritive value for domestic ruminants. Here, we investigate the intake and digestibility by sheep of different reed canary-grass growth stages.

MATERIALS AND METHODS

Cultivation and sampling of experimental grass

RCG was cultivated in the experimental field of the Fuji Animal Research Farm, Nippon Veterinary and Life Science University, Yamanashi, Japan, and was harvested during first growth (mid-June) and second regrowth (mid-August), each at the pre-blooming stage. The grass was harvested three times (07:00, 12:00, and 17:00) per day during each five-day experimental period. On each occasion, stems and leaves were separated by hand and 3 kg (fresh weight) of either stems or leaves was offered to each experimental sheep.

Chemical analysis and measurement of gross energy content

After separating stem and leaf from RCG, grass samples were dried overnight at 60 °C to measure dry mass (DM) and moisture content, ground in a Wiley mill to pass a 1 mm screen, and stored in sealed bottles until analyzed. Ground samples of RCG were used for crude protein and fat analysis by the Kjeldahl method according to the AOAC [4] and detergent fiber determined by the method of Goering and Van Soest [5]. The gross energy content of all samples was measured in an oxygen bomb calorimeter (Yoshida, Co. Ltd., Tokyo, Japan). Each analysis was performed in triplicate.

Observation of feeding behavior and measurement of dry matter digestibility

Three sheep (female, Southdown, average body weights: 53.6 kg at first and 58.1 kg at second experiment) were used. Each sheep was kept in a pen and was fed 3 kg of fresh RCG at three times (07:00, 12:00, and 17:00) each day. The sheep had free access to fresh water and a salt-mineral block. Feeding behavior, including intake frequency, eating time, and bite count, was recorded directly by the operators until eating was suspended after 15 min, or when rumination commenced. Grass residue and excrement were collected at each feeding time, dried at 60 °C for several days, and used to measure forage intake and digestibility.

Statistical analyses

Statistical differences between measurements were analyzed by multiple *t*-tests. When a significant difference was found, further comparison was made using Tukey's method [6].

RESULTS AND DISCUSSION

Chemical composition

Table 1 shows the chemical composition of reed canary-grass cut at the pre-blooming stages of both the first and second cuts. The proportions of stem and leaf tissue in the cuts, expressed as dry matter, were 62.0% and 29.0%, respectively at first cut, and 44.0% and 56.0%, respectively at second cut.

Table 1. Chemical composition[1)] of reed canary-grass cut at different stages

Stage	First cut			Second cut	
Component	Stem	Leaf	Ear	Stem	Leaf
Moisture	83.5	81.4	78.0	85.3	75.4
CP[2)]	9.3	26.1	19.0	16.2	30.0
Fat	1.2	3.7	2.7	1.3	3.7
NDF	70.9	52.1	56.8	60.1	49.1
ADF	42.0	24.4	27.1	32.9	22.2
ADL	4.0	1.8	6.7	2.5	1.9
Energy[3)]	4119.9	4591.8	4524.1	3835.8	4461.7
Digestibility	57.0	70.9	63.3	62.9	65.7

1) Percentage of dry matter basis (except for moisture) 2) Crude protein
3) cal/g dry matter

The proportion of crude protein (CP) was significantly higher in leaves harvested at the second cut than in the other samples. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were higher in stems than in leaves in both the first and second cuts. Gross energy content was slightly lower in stems of the second cut than in the other samples. Dry matter digestibility of leaves was significantly higher than that of stems in the first cut but there was no difference between stems and leaves in the second cut.

Tokita et al. [2] reported that the CP contents of stems and leaves of RCG harvested in June at the pre-blooming stage at the first cut were 14.2% and 20.2%, respectively, and at the second cut at pre-blooming stage in August, they were 6.1% and 14.3%, respectively. Similarly, the CP contents of leaves were higher than those of stems in the present experiment. However, the CP contents of the stems and leaves at second cut in this experiment were 2.6 and 2.1 times higher, respectively than the values in the above report. In contrast, fiber contents of RCG (NDF and ADF) were similar to those reported in the former study. Tokita et al. [2] also measured the digestibility of RCG using an *in vitro* method; the values were very similar to those obtained in our experiment.

Feeding behavior

When 3 kg of fresh RCG was fed to each sheep, the total food intake was 296.1 g (dry matter) in the second cut and was significantly higher than that in the first (Table 2). Although the food intake was higher in the second cut, the eating time (69.4 min) and total bite count (4405.3) were significantly higher in the first cut.

Table 2. Feeding behavior of sheep fed 3 kg of different stages of fresh reed canary-grass

	First cut	Second cut	(Second/First)
Forage intake, g DM	214.1[a]	296.1[b]	1.4
Intake frequency, count	170.5	161.4	0.9
Eating time, min	69.4[b]	54.9[a]	0.8
Total bites, count	4405.3[b]	3025.9[a]	0.7
Forage intake, g DM/$BW^{0.75}$	10.3a	13.9[b]	1.3
Rate of biting, bites/min	64.8[b]	54.6[a]	0.8
Bite size, g DM	0.05[a]	0.10[b]	1.9

Different superscript letters indicate significant differences between first and second cuts ($p<0.05$). DM, dry mass; BW, body mass.

Therefore, forage intake, scaled to the metabolic body mass of the sheep, was 10.3 g DM/$BW^{0.75}$ from the first cut and significantly lower than that at the second cut. Furthermore, the rate of biting in the first cut (64.8 bites/min) was significantly higher than in the second cut. This observation indicates that the selectivity for the stage of grass by Southdown sheep in this experiment was superior at the second cut.

Nutrient intakes of sheep

Dry matter and CP intakes from the leaves were higher than intakes from the stems in both the first and second cuts. Dry matter intake from leaves was 129.0 g in the first cut and 230.3 g in the second (significantly different, $p<0.05$).

Table 3. Nutritional intakes of sheep fed 3 kg of fresh reed canary-grass of different stages

	First cut		Second cut	
	Stem	Leaf	Stem	Leaf
DM[1)]	54.6	129.0	65.8	230.3
CP[2)]	5.1	33.7	10.7	69.1
Fat	0.7	4.7	0.9	8.5
NDF	38.7	67.2	39.5	113.1
ADF	22.9	31.5	21.6	51.1
ADL	2.2	2.3	1.6	4.4
Energy[3)]	224.8	592.5	252.4	1027.3

1) Dry matter, g. 2) Crude protein. 3) kcal/g DM.

The total dry matter intakes of RCG in this experiment were 214.1 g at the first cut and 296.1 g at the second (Table 2), and mainly consisted of leaf material rather than stem tissue in both the first and second cuts (Table 3). The different intakes reflect the different proportions of plant structural components, i.e., the ratio of stem to leaf material was lower in second cut than in the first.

Poppi et al. [7] demonstrated that the particle size of grass hay escaping from the rumen of sheep was related to its digestibility and voluntary food intake. The critical size of particles generated by mastication and rumination in sheep and transferred on is <1.18 mm. Playne [8] compared digestibility of low-quality hays by cattle and sheep. Digestibility was higher for cattle than for sheep and the difference was greatest with the samples of lowest digestibility. In our experiment, the intakes of stem material from both first and second cuts were lower than the intakes of leaf material. The digestibility of the stem fraction showed a similar pattern in this experiment. These observations suggest that the physical hardness of the stems of RCG resists their breakdown to small particles by the rumen microbes and the rumination process. Consequently, RCG leaf material is consumed in greater quantity by sheep and is more fully digested compared with the stem fraction. Nakanishi et al. [9] studied selective grazing (feeding behavior) of goats fed a tropical grass (Rhodes grass, *Chloris gayana*) and a legume (siratro, *Macroptilium atropurpureum*) and showed that the dry matter intake per bite (defined similarly) ranged from 0.045 to 0.078 g DM in siratro and from 0.045 to 0.037 g DM in Rhodes grass. These values correspond to those of leaf material of RCG in the second cut.

CONCLUSION

The intake and digestibility by sheep of different reed canary-grass (RCG) growth stages were measured. It was shown that: (1) When adult female Southdown sheep were each fed 3 kg of fresh RCG three times per day, the dry matter digestibility of RCG was significantly higher for leaf material than for stems regardless of harvesting period. (2) Fibrous components (neutral and acid detergent fibers) were higher in the stems than in the leaves but crude protein content was higher in the leaf fraction. (3) Dry matter intake of RCG was 296.1 g at the second cut and was significantly higher than at the first cut. The eating time for consumption of dry matter at the second cut was 54.9 min and was shorter than at the first cut. (4) Consequently, at the second cut, the rate of biting (54.6 bites/min) was lower than at the first cut. The bite size, expressed as dry matter intake per bite, ranged from 0.05 g at the first cut to 0.10 g at the second cut.

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