Grazing Behavior and Rumen Characteristics of Japanese Black cattle in Native Pasture

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Abstract

Grazing behavior and rumen characteristics of Japanese Black Cattle were examined on two paddocks (B:1st trial and C:2nd trial) in a native pasture with different botanical composition. The grazing pattern and rumination time of three animals showed variations between paddocks B and C on 24 hour behavioral observations. An increase in grazing time on the paddock C was observed as compared to the paddock B. Diet selection was evaluated by bite count method. In paddock B, the cattle grazed initially *Imperata cylindrica* more highly but later *Miscanthus sinensis* and *Eremochloa ophiuroides* by bite count method. The cattle selected *M. sinensis* as the first choice for a few days after transfer to the paddock C, and *I. cylindrica* and *E. ophiuroides* more during the later stage of grazing period. Total volatile fatty acids (VFA) concentrations in the rumen fluid were higher in the samples collected on the 7th or 9th day than on the 1st day of the grazing before transfer, irrespective of paddocks (paddock B:5.27 to 6.76 mmol dl^{-1}, paddock C:6.87 to 7.53 mmol dl^{-1}). NH_3-N concentration in the rumen fluid remained stable around 4.33 mg dl^{-1}. Total protozoa counted $3.0x10^5$ ml^{-1} on the 4th day after moving and similar during the 1st trial, while in the 2nd trial $4.1x10^5$ ml^{-1} on the 4th day after moving and then increased to $5.9x10^5$ ml^{-1} on the 9th day. Total protozoa counted higher in the 2nd trial than in the 1st one. Number of bacteria ranged from $1.1x10^9$ ml^{-1} to $7.1x10^9$ ml^{-1} and cocci (-) and cocci (+) were detected in large percentages throughout the experimental period.

Key Words:Diet selection, Japanese Black cattle, Native pasture, Rumen fluid, VFA

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INTRODUCTION

Grazing of beef and dairy cattle on native pasture has been done extensively over the years in rural areas of Japan as a means of providing forage for cattle. Due to reasons such as low animal production[7,8], this system is not considered as efficient as sown pastures. To develop a sustainable native pasture-grazing system, it is important to characterize the behavioral adaptation of animals and evaluate the potential of feeding animals on various native pastures. *Imperata cylindrica* is a very common and useful native plant species for grazing livestock[9] in Japan. There are much possibility of grazing animals on Nezasa dwarf bamboo[18]. However, the nutritional characteristics of *Pleioblastus simonii* have not yet been examined.

This study was carried out to examine the grazing behavior and rumen fermentation characteristics of Japanese Black Cattle on the native pasture of predominant species of *I. cylindrica* and *P. simonii*, which are commonly distributed in southern Japan.

MATERIALS AND METHODS

Three adjacent paddocks A (1.0ha), B (1.2 ha) and C (0.8ha) in the native pasture at Miyazaki University were used for the grazing experiment of three pregnant Japanese Black cows. The grazing trials on paddocks B and C were conducted between September 20th and 29th and between October 10th and 26th, respectively. The animals were set-stocked on paddock A before the first grazing trial from September 8th and intermediate between the two grazing trials. Animals were also allowed to access to mineral salts but not any feed supplements.

Plant species, percentages of herbage composition, and standing fresh weights in paddocks B and C were measured before grazing and after 10 days of grazing, by a quadrat method of monitoring 6 and 4 sections, respectively.

The observation of animal behavior was conducted twice each for 24 hour on the 2nd and 9th day after the start of grazing in paddocks B and C, respectively. The behavioral types of grazing, rumination, resting and others with postures lying and standing were recorded every 2 min. throughout the day, and the plant species and bite size of each plant species selected by a representative animal was recorded at first grazing period which usually occurred during early morning[5]. The body weights of the animals were also measured at each time of changing the paddock.

Rumen contents of the representative of the three grazing animals were consistently collected at 1 h after the first grazing in the morning of the 1st, 4th and 7th day in the paddock B, and in the morning of the 1st, 4th, 9th and 16th day in the paddock C. A portion of the samples of rumen fluid collected by rumen cannula, was filtrated with double cheese cloth and fixed with methyl green formalin saline solution to determine the number and compositional percentage of protozoa and bacteria, respectively[14]. The bacterial number was also counted according to the gram-staining and shapes, after a fixation of 20%formalin saline solution.

The rumen samples were also immediately subjected to measurement of rumen pH and then kept at −20℃ until appropriate analysis. The concentrations of volatile fatty acids (VFA) and NH_3-N were determined by high pressure liquid chromatograph (Shimadzu, LC-10) equipped with Shim-pack SCR-102H (8 mmI.D*300mmL)) and by a Kjeldahl method[2], respectively.

RESULTS AND DISCUSSION

(1) Pasture condition, animal behavior, and diet selection

On paddock B the standing and grazed mass were around 432g m^{-2} and 216g m^{-2}, respectively, suggesting possibly abundant intake of grazing animals under a moderate grazing pressure as shown by a 50% of mass utilization observed in this study (Table 1). Among 11 plant species detected, the majors were *Imperata cylindrica, Hemarthria sibirica, Paspalum dialatum, Eremochloa ophiruoides, Carex lenta, Pleioblastus Simonii,* and *Miscanthus sinensis*, showing the initial coverage of 56.7%, 27.5%, 17.5%, 12.5%, 10.0%, 6.7% and 6.3%, respectively. The three majors were also preferred by animals more than other species, resulting in decreases of the coverage of 29.2%, 2.8%, and 0.3% at the end of grazing, respectively.

The frequency of grazing *I. cylindrica* and *M. sinensis* was also initially higher than *E. ophiuroides*, which was chosen the most at later period of grazing (Table 2). Decrease in grazing of one particular species and an increase in grazing of another species has been reported by J. S.FEHMI *et al.*[3]. Shifts in preference could be based on the nutritional quality of the forage[10] and also due to the expo-

Table 1. Change of plant composition and standing mass in paddock B and C before and 10 days after cattle transfer from A

Items	Paddock B					
	before transfer	after transfer	Difference	before transfer	after transfer	Difference
	(a)	(b)	(b)−(a)	(c)	(d)	(d)−(c)
Plant composition, %of coverage*						
Imperata cylindrica	56.7	29.2	−27.5	33.4	40.0	+6.6
Hemarthria sibirica	27.5	2.8	−24.7	12.0	8.0	−4.0
Paspalum dialatum	17.5	0.3	−-17.2	0	0	0
Eremochloa ophiuroides	12.5	33.3	+12.8	14.0	5.0	−9.0
Carex lenta	10.0	0	−10.0	0	0	0
Pleioblastus simonii	6.7	8.3	+2.6	1.0	1.0	0
Miscanthus sinensis	6.3	7.5	+1.2	35.0	21.0	−6.0
Wisteria floribunda	5.0	0	−-5.0	0	0	0
Linum virginianum	3.3	0	−3.3	0	0	0
Juncus effusus	2.8	11.7	+8.9	0	0	0
Solidago altissima	1.2	0	−1.2	3.0	6.0	+3.0
Arthraxon hispidus	0	0	0	1.7	0	−1.7
Hydrocotyle sibthorpiodes	0	0	0	0.1	0	−0.1
Eragrostis curvula	0	0	0	4.0	0	−4.0
Sporobolus fertilis	0	0	0	0.4	0	−0.4
Standing and grazed mass, gDM m^{-2}, Average±S.D						
	432.4±210.0	216.3±83.8	216.1±177.3	213.5±108.8	178.4±94.3	80.9±111.2

* Data were evaluated by 1 x 1m^2 quadrats on 6 sectons in paddock B and on 4 sections in paddock C.

Table 2. Change of morning grazing time and bite counts of 5 main plants grazed by Japanese Black Cattle in paddock A and B on the 1st trial.

Items	Paddock A	Paddock B	
	The day before transfer to B204	4th day after transfer144	7th day after transfer
Total grazing time, mins	204	144	203
Bite count, bite hr^{-1}			
Plants			
Imperata cylindrica	661.5	739.2	253.0
Eremochloa ophiurides	223.2	0.0	309.8
Pleioblastus simonii	0.0	5.4	16.0
Miscanthus sinensis	174.1	523.8	55.0
Solidago altissima	0.0	0.0	14.5

Table 3. Change of morning grazing time and bite counts of 5 main plants grazed by Japanese Black Cattle in paddock A and C on the 2nd trial.

Items	Paddock A	Paddock C		
	The day before transfer to C	4th day after transfer	9th day after transfer	16th day after transfer
Total grazing time, mins	256	233	266	321
Bite count, number hr^{-1}				
Plants				
Imperata cylindrica	62.1	93.5	98.1	15.8
Eremochloa ophiurides	64.7	32.5	78.9	3.8
Pleioblastus simonii	1.6	0.0	0.0	1.1
Miscanthus sinensis	209.3	175.9	172.5	71.1
Solidago altissima	1.2	10.0	0.0	13.8

sure to new forages[4]. Although *I. cylindrical* and *M. sinensis* were more highly grazed by animals similar as paddock A, the frequency of grazing *E. ophiuroides* was not so high with showing difference from paddock A. This difference would be partially related with a lower total grazing time on paddock B compared to that of paddock A. However, the grazing frequency of the vegetations was inconsistent with changes in the compositional coverage by grazing animals.

On paddock C the standing and grazed mass were around 214g m^{-2} and 81g m^{-2}, respectively, suggesting severe shortage of DM intake of grazing animals as estimated by available biomass and stocking rate (Table 1). However, total grazing time on paddock C was not different from that of paddock A, except for that on the 16th day of grazing, although the bite size on paddock C was much lower than the paddock B. The major species observed were similarly *M. sinensis*, *I. cylindrica*, *E.ophiruoides*, and *H. sibirica*, showing the coverage of 35%, 33.4%, 14% and 12%, respectively. *E. ophiruoides* and *M. sinensis* were preferentially grazed more than other species, as shown by the frequency of grazing (Table 3). Therefore, the coverage of *E. ophiruoides* and *M. sinensis* were decreased to 21% and 5%, respectively. Conside rable reduction in the frequency of grazing of *M. sinensis* by moving paddock C from paddock A and by extending grazing period was also accompanied with slight increase of grazing frequency of *I. cylindrical.* Similarly as on paddock B, the frequency of grazing vegetations on paddock C was inconsistent with changes in the compositional coverage by grazing animals. Thus, the selection of vegetation by grazing animals observed in this study appeared extremely to be dependent upon the vegetation structure of resting area at the start of grazing in the early morning.

No differences in the grazing pattern between paddocks A and B were observed as shown by around 40% and 21% of percentages of grazing time and rumination time, respectively (Fig. 1). The intensive grazing, as occupied over 25% of total by grazing, was observed to start around 6 am and continuously to appear until 6 pm, although occasionally intensive grazing was observed at midnight (Fig. 2). On the other hand, the percentage of grazing time increased 38% to 45% of the total by changing paddock from A to C (Fig. 3). Among the grazing behavior categorized in this study, a distinct difference between paddocks B and C was observed with rumination time, as shown by around 35% of the total on paddock C. The difference would be explained by decreases in the nutritive quality of each of herbage with increasing growth stage and maturation and differences of herbage composition between two paddocks. H ASEGAWA and HIDARI[6] reported distinct behavioral adaptation of heifers in accordance to changes in the quality and quantity of pasture. They observed that either low quality, small quantity of herbage, or both can induce a prolonged grazing time in native pasture. Since *I. cylindrica*, the major herbage on paddock B, is generally more digestible than *E. ophiuroides* and *M. sinensis*, the majors on paddock C, the animals probably needed to spend more time for rumination on paddock C. However, the greater rumination time on paddock C was not known to be associated with shift of grazing pattern, which showed thecontinuously intensive grazing between 2 pm afternoon and 2 am midnight, although this shift is not explained in this study (Fig. 4).

(2) Rumen characteristics

Both on paddock B and C, the pH and ammonia concentration were the same (Tables 4 and 5). Ammonia concentrations observed in this study were therefore slightly lower than 5mg dl^{-1} of optimal concentration in the rumen which was reported for efficient microbial growth by SATTER and SLYTER[16]. However, it was higher than the value of 2mg dl^{-1} of concentration proposed for optimal fiber digestion by PETERSON[15].

VFA concentrations in the rumen of grazing cattle can be reflected in quantitative and qualitative conditions of herbage in the pastures, being associated with the nutritional and health conditions of animals. On paddock B the major VFA detected was higher in the

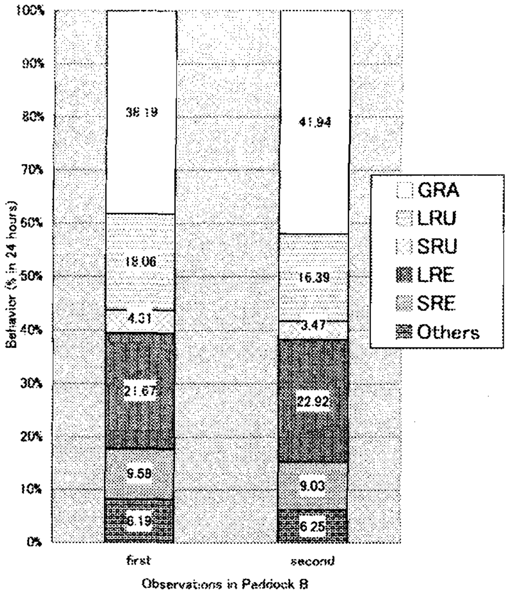

Fig 1. 24-hour behavior of Japanese Black Cattle in Paddock B.
GRA:grazing, LRU:lying rumination, SRU:standing rumination, LRE:lying resting, SRE:standing resting, Others:other behavioral categories.

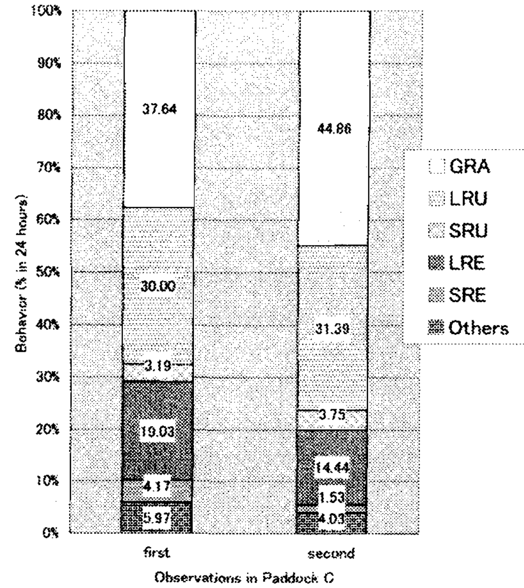

Fig 3. 24-hour behavior of Japanese Black Cattle in Paddock C.
GRA:grazing, LRU:lying rumination, SRU:standing rumination, LRE:lying resting, SRE:standing resting, Others:other behavioral categories.

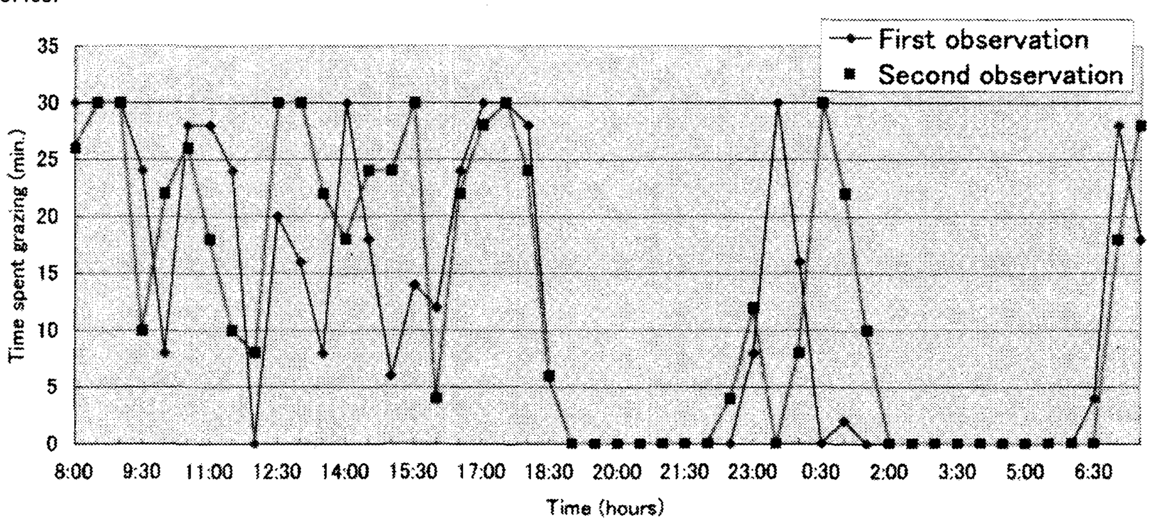

Fig 2. Grazing pattern of Japanese Black Cattle in paddock B.

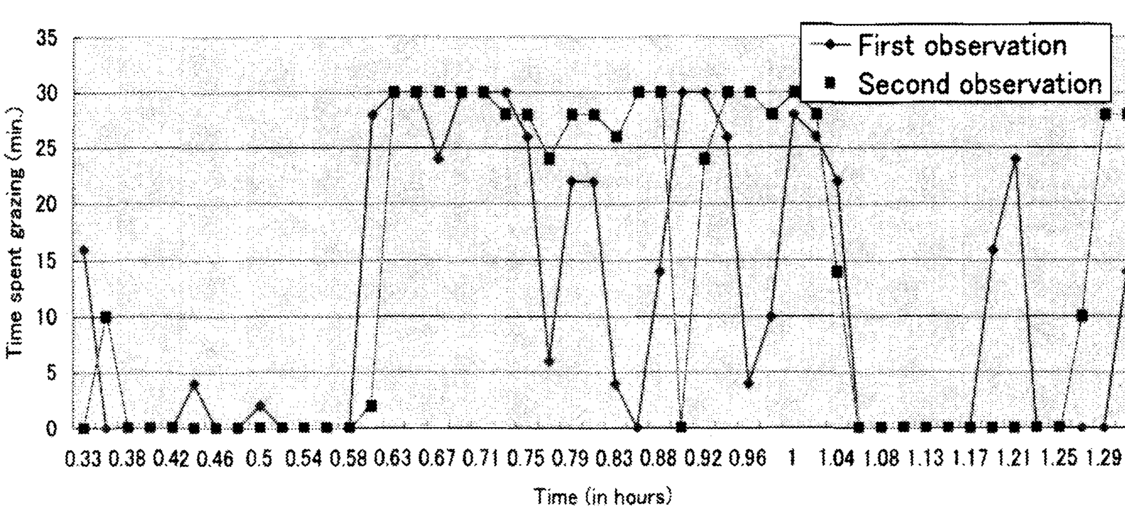

Fig.4. Grazing pattern of Japanese Black Cattle in paddock C.

order of acetate, propionate, and butyrate, remaining stable at 5.9-6.1 of a ratio of acetate to propionate (Table 4). Total VFA concentrations in the rumen of animals grazing on paddock B was higher at 6.76 mmol dl^{-1} on the 7th day than both 5.27mmol dl^{-1} on paddock A and 5.48 mmol dl^{-1} on 4th day, although the compositional percentage of each VFA was almost same between them. On paddock C total VFA concentrations were higher on 9th day than on 4th and 16th day, ranging from 6.45 mmol dl^{-1} on 16th day to 7.53 mmol dl^{-1} on 9th day (Table 5). Therefore, total concentration was consistently higher on paddock C than on paddock B, while a ratio of acetate to propionate was inversely higher on paddock B than paddock C. Though generally decreases in total VFA concentration with advancing grass maturity have been reported for a variety of forage types[1,11,12], MCCRACKEN *et al.*[13] reported the fluctuation in total VFA concentration with advancing maturity of tall fescue with steers grazing. The present result would be therefore attributable to wide range of diet selection in the native pasture, which can lead to better intake of high quality of forage and rumen fermentation of grazing animals. The quantitative inferiority of paddock C to paddock B, as described above, was considerably improved by behavioral adaptation of grazing animals such as diet selection and greater rumination time. Thus, it would be important to estimate the grazing capacity of native pasture by evaluating characteristics of rumen fermentation of animals as well as vegetation structure of the pasture.

(3) Composition percentages of bacteria and protozoa in the rumen

Total number of the bacteria in the rumen of grazing animals on paddocks B and C was 1.0-7.0 x 109 cells ml^{-1} of rumen contents (Table 6 and 7). The major one was consistently the gram-negative cocci, ranging 50-60% of the total on paddock B and 42-82% of that on paddock C. Apart from the major, the rest was the gram-positive on paddocks B and C. The bacteria in the rumen of grazing animals composed of gram-negative and

Table 4. Change of body weight and rumen fluid parameters of Japanese Black Cattle in the 1st trial.

Items	Paddock A	Paddock B	
	the day before transfer449	4th day after transfer455	7th day after transfer
Body weight, kg	449	455	460
Rumen fluid			
pH	7.22	7.52	7.11
Total VFA, mmol dl^{-1}	5.27	5.48	6.76
Acetic acid, %	71.83	70.07	72.60
Propionic acid, %	12.21	11.54	12.27
Iso-butyric acid, %	7.68	9.99	7.44
N-butyric acid, %	8.28	8.40	7.69
Acetic acid/propionic acid	5.88	6.07	5.91
NH_3-N, mg dl^{-1}	4.33	3.61	4.33

Table 5. Change of body weight and rumen fluid parameters of Japanese Black Cattle in the 2nd trial.

Items	Paddock A	Paddock C		
	The day before transfer	4th day after transfer455	9th day after transfer	16th day after tranfer
Body weight, kg	–	455	460	460
Rumen fluid				
pH	7.09	7.34	7.22	7.53
Total VFA, mmol dl^{-1}	6.87	6.88	7.53	6.45
Acetic acid, %	73.69	71.27	72.29	72.25
Propionic acid, %	12.95	13.00	13.02	12.70
Iso-butyric acid, %	4.86	7.52	6.80	6.78
N-butyric acid, %	8.49	8.20	7.88	8.25
Acetic acid/propionic acid	5.70	5.48	5.55	5.68
NH_3-N, mg dl^{-1}	4.33	3.61	2.89	4.33

Table 6. Change of rumen microflora of Japanese Black Cattle in the 1st trial.

Items	Paddock A	Paddock B	
	The day before transfer	4th day after transfer	7th day after transfer
Protozoa			
Total, cells ml-1	5.4×10^5	3.0×10^5	3.7×10^5
Entodinium, %	74.07	68.75	67.57
Diplodinium, %	16.66	18.75	21.62
Dasytrichia, %	9.25	12.75	2.70
Epidinium, %	nd	nd	8.10
Bacteria			
Total, cells ml^{-1}	1.1×10^9		
cocci (+), %	43.43	2.0×10^9	5.7×10^9
cocci (−), %	20.20	18.18	29.85
cocci pair (+), %	3.03	59.36	49.62
cocci pair (−), %	4.04	4.81	3.04
clusters (−), %	10.10	8.56	8.37
cocci chain (+), %	2.02	nd	1.52
cocci chain (−), %	2.02	nd	nd
rod square (+), %	4.04	2.14	1.33
rod round (+), %	7.07	nd	nd
rod round (−), %	4.04	nd	0.19
cocci tetra (+), %	nd	nd	1.14
cocci tetra (−), %	nd	6.42	0.19
curved rod (+), %	nd	0.53	1.33
curved rod (−), %	nd	nd	0.19
borrelia (−), %	nd	nd	3.04

Table 7. Change of rumen microflora of Japanese Black Cattle in the 2nd trial.

Items	Paddock A	Paddock C		
	Day of transfer	4th day after transfer	9th day after transfer	16th day after transfer
Protozoa				
Total, cells ml^{-1}	9.8×10^5	4.1×10^5	5.7×10^5	5.9×10^5
Entodinium, %	72.44	78.78	84.21	67.79
Diplodinium, %	16.32	15.00	10.52	22.03
Dasytrichia, %	5.10	nd	5.26	10.16
Epidinium, %	nd	6.06	nd	nd
Bacteria				
Total, cells ml^{-1}	5.0×10^9	6.5×10^9	7.1×10^9	3.4×10^9
cocci (+), %	4.58	5.55	5.49	7.57
cocci (−), %	81.70	82.18	42.07	76.02
cocci pair (+), %	1.09	0.84	2.13	2.21
cocci pair (−), %	5.45	5.21	13.11	3.79
clusters (−), %	nd	0.17	0.15	nd
cocci chain (+), %	nd	0.17	0.30	0.32
cocci chain (−), %	nd	nd	0.15	0.63
rod square (+), %	1.31	1.01	1.22	1.89
rod round (+), %	nd	nd	0.46	nd
rod round (−), %	nd	0.67	0.30	nd
cocci tetra (+), %	0.22	nd	0.91	nd
cocci tetra (−), %	nd	nd	1.22	nd
curved rod (+), %	0.22	nd	0.46	nd
curved rod (−), %	nd	nd	1.68	0.63
borrelia (−), %	nd	0.84	nd	0.95

gram-positive cocci in this study. As characterized for changes in the microflora of the grazing on paddock B, the gram-positive cocci increased on later period of grazing, while the gram-negative cocci decreased. In contrast, there was a drop in the compositional percentage of the gram-negative cocci on 9th day after the grazing on paddock C.

Total number of protozoa remained stable around $3.0\text{-}9.0 \times 10^5$ cells ml^{-1} of rumen contents, irrespective of grazing paddocks A or B (Table 6 and 7). Similar as typical feeding conditions, *Entodinium* spp. was the first major species by a 73% of averaged percentage of paddocks B and C, while Diplodinium spp. was the second major by 18%. The others detected were *Dasytrichia* spp., *Epidinium* spp., and *Polyplastron* spp.. As characterized for paddock B, the grazing induced to increased composition of *Epidinium* spp. and lowered that of *Dasytrichia* spp.. In accordance of the shift to a type of *Epidinium* spp., the compositional percentage of *Diplodinium* spp. was increased. In contrast on paddock C, the grazing induced to increased composition of *Dasytrichia* spp. and lowered that of *Epidinium* spp., while the compositional percentage of *Diplodinium* spp. was similarly increased. The compositional percentage and cell number of the rumen microorganisms, bacteria, protozoa, and fungi, can be reflected by the nutritional conditions such as diet type and feeding frequency[17]. Among various protozoal species detected in the rumen, *Diplodinium* spp., *Dasytrichia* spp., *Epidinium* spp., and *Polyplastron* spp., are the fiber-degrading protozoa, which can contribute to over 20% of fiber degradation in the rumen.

(4) Conclusion

The present study shows that the native plant species, *Imperata cylindrica*, *Miscanthus sinensis*, *Eremochloa ophiuroides* were highly selected grasses and *Pleioblastus simonii* though chosen less. The choice in diet influenced both microbial count and VFA concentration. Though the results in both trials were nearly similar, the vegetation in the 2nd trial produced better results. Behavior studied and rumen characteristics show that cattle are able to adapt to the types of native grasses and maintain their body weight.

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野草地放牧における黒毛和種牛の採食行動とルーメン内性状

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要　約

植物種構成の異なる野草放牧地２パドック（Ｂ：実験１，Ｃ：実験２）で、黒毛和種牛の行動観察とルーメン液採取を行った。24時間行動観察において、採食行動パターンと反芻時間は両パドック間で違いを示し、採食時間はパドックＣでパドックＢよりも長かった。バイトカウント法による採食植物観察では、パドックＢ入牧直後には *Imperata cylindrica* の採食割合が高く、後に *Miscanthus sinensis* と *Eremochloa ophiuroides* の採食割合が増加した。パドックＣでは入牧後数日間は *M. sinensis* を最も多く選択したが、後には *I. cylindrica* と *E. ophiuroides* の採食割合が高くなった。ルーメン液中総ＶＦＡ濃度はどちらの牧区も、実験１日目入牧前よりも実験７日目または９日目に高く（それぞれ，パドックＢ:5.27，6.76mmol dl^{-1}，パドックＣ:6.87，7.53mmol dl^{-1}）、NH_3-N 濃度は4.33mg dl^{-1} でほぼ一定であった。総プロトゾア数は、実験１では４日目$3.0x10^5ml^{-1}$でその後ほぼ一定であったが、実験２では４日目$4.1x10^5ml^{-1}$から９日目$5.9x10^5ml^{-1}$に増加した。総プロトゾア数は実験２において実験１よりも多かった。バクテリア数は$1.1x10^9ml^{-1}$ ～$7.1x10^9ml^{-1}$で変動し、cocci（－）と cocci（＋）が実験期間中を通して多かった。

キーワード：飼料選択，黒毛和種，野草地，ルーメン液，VFA

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