Comparison of Intake, Digestibility and Nutritive Value of *Sasa nipponica* in Hokkaido Native Horses on Summer and Winter Woodland Pasture

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Synopsis


Amount of intake, digestibility and nutritive value of *Sasa nipponica* foliage in Hokkaido native horses were determined on woodland by the double-indicator method and compared among seasons, i.e. summer, non-snowy periods in winter and snowy periods in winter. The total number of mares and fillies used for experiment were 9 and 3 in summer, 4 and 9 during non-snowy periods in winter and 4 and 6 during snowy periods in winter. The dry matter intake of *Sasa nipponica* foliage was significantly higher in summer and during non-snowy periods in winter than that during snowy periods in winter (P<0.05). The apparent digestibility of NDF in winter was lower than that in summer (P<0.05). The contents of DCP and DE were 9.2% DM and 1.73 Mcal/kg DM in winter, and were similar to those in summer. The DCP intake of mares and fillies were more than the maintenance requirements (NRC, 1989) of the horses in all seasons. The DE intake of mares was found to be less than the maintenance requirement of the horses during snowy periods in winter, resulting into their body weight losses during this experimental periods. The DE intake of fillies were more than maintenance requirement in all seasons, while their body weight increased in summer and during non-snowy periods in winter, and maintained during snowy periods in winter.

Key words: Digestibility, Hokkaido native horses, Intake, Nutritive value, *Sasa nipponica*, Woodland pasture.

Introduction

Hokkaido native horses are mostly maintained in Hokkaido, the northernmost part of Japan. For over a century, these animals have been used as pack horses in Hokkaido. They have been kept outdoors all year round, including in woodland pastures during winter, and grazed on sasa growing under trees, which occupies about 70% of the underlayer of Hokkaido forest. There are three types of sasa in Hokkaido, i.e. large, middle and small sized sasa. *Sasa nipponica* is a kind of small sized sasa, whose plant length is not more than 1 m, and principally this small sized sasa has been used for grazing of Hokkaido native horses. The above ground part of *Sasa nipponica* consists of foliage and culm, and horses graze on the foliage mainly. Although the digestibility of *Sasa nipponica* foliage is superior in terms of crude protein (CP) content and CP digestibility, the amount of *Sasa nipponica* would easily decline if these areas were overgrazed. Therefore, in order to sustain the utilization of *Sasa nipponica* growing in woodland pastures with the optimum stocking rate, the voluntary intake of *Sasa nipponica* foliage should be measured under actual grazing conditions.

The seasonal changes of the chemical compositions of *Sasa nipponica* foliage are slight, especially the CP content of *Sasa nipponica* foliage in winter is similar to that in summer. However, the intake, digestibility and nutritive value of *Sasa nipponica* foliage in Hokkaido native horses under grazing conditions have never been investigated yet. In this study, the intake and digestibility of *Sasa nipponica* foliage grazed by Hokkaido native horses were determined during summer, non-snowy periods in winter and snowy periods in winter under grazing conditions in woodlands so as to be able to relate the nutritive value of *Sasa nipponica* foliage among seasons.

Materials and methods

The experiments were carried out in the Livestock Farm and the Tomakomai Experimental Forest of Hokkaido University, located in Hidaka and Iburi...
Table 1. Characteristics of each experimental paddock, total number of horses used for experiments and time of fecal collection.

<table>
<thead>
<tr>
<th>Season</th>
<th>Summer</th>
<th>Non-snowy winter</th>
<th>Snowy winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddock no.</td>
<td>T-419</td>
<td>T-117</td>
<td>F-10</td>
</tr>
<tr>
<td>Area (ha)</td>
<td>0.75</td>
<td>2.25</td>
<td>10.5</td>
</tr>
<tr>
<td>Elevation difference (m)</td>
<td>0</td>
<td>0</td>
<td>90</td>
</tr>
<tr>
<td>Snow depth (cm)</td>
<td>—</td>
<td>—</td>
<td>70</td>
</tr>
<tr>
<td>No. of horses (Mare)</td>
<td>9</td>
<td>—</td>
<td>40</td>
</tr>
<tr>
<td>(Filly)</td>
<td>—</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Time of fecal collectiona</td>
<td>6th</td>
<td>6th</td>
<td>6th</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6th</td>
<td>6th or 10th</td>
</tr>
</tbody>
</table>

a) The day after entrance into paddock.

Table 2. Chemical composition and energy content of *Sasa nipponica* foliage.

<table>
<thead>
<tr>
<th></th>
<th>DM</th>
<th>OM</th>
<th>CP</th>
<th>EE</th>
<th>NDF</th>
<th>GE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>% DM</td>
<td></td>
<td></td>
<td></td>
<td>Mcal/kgDM</td>
</tr>
<tr>
<td>Summer</td>
<td>35.7ab</td>
<td>88.8</td>
<td>15.8</td>
<td>3.7</td>
<td>70.1</td>
<td>4.50</td>
</tr>
<tr>
<td>Winter (Non-snowy)</td>
<td>49.8</td>
<td>85.8</td>
<td>12.5</td>
<td>3.9ab</td>
<td>58.4</td>
<td>4.28</td>
</tr>
<tr>
<td>(Snowy)</td>
<td>25.4a</td>
<td>86.2</td>
<td>13.8b</td>
<td>2.6a</td>
<td>62.6</td>
<td>4.48</td>
</tr>
</tbody>
</table>

DM: Dry matter, OM: Organic matter, CP: Crude protein, EE: Ether extract, NDF: Neutral detergent fiber, GE: Gross energy

The day after entrance into paddock.

The voluntary intake, digestibility and nutritive value of *Sasa nipponica* foliage were estimated by double-indicator method using chromic oxide (Cr₂O₃) and acid insoluble ash (AIA). From the beginning of their grazing on the each experimental paddock, the horses were fed 50g of pellets each, which consisted of 10% Cr₂O₃, 60% wheat bran and 30% defatted rice bran at 8 a.m. and 4 p.m. everyday. Feces of each horse were collected for 24 hours on 6th or 10th day from the beginning of their grazing on each paddock. Time of fecal collection are shown in Table 1 as the day after entrance into paddock. On the day before each fecal collection, samples of *Sasa nipponica* foliage were collected from each paddock for determining chemical compositions and energy contents. The recovery rates of Cr₂O₃ and AIA were regarded as 100 and 90%, respectively, according to the previous study.

Samples of *Sasa nipponica* foliage and fecal output were dried at 60°C for a minimum of 72 hr, ground and passed through a 1 mm screen to determine their chemical compositions and energy contents. The dry matter (DM), organic matter (OM), crude protein (CP) and ether extract (EE) contents were analyzed according to the conventional methods. Analysis of the neutral detergent fiber (NDF) was done by the method of Van Soest and the gross energy (GE) was determined with a bomb calorimeter (CA-3 type: Shimadzu, Japan). The Cr₂O₃ contents of the pellets and feces were determined by the method using potassium phosphate reagent. The AIA contents of *Sasa nipponica* foliage and feces were determined by the method of Van Keulen and Young using 2N-hydrochloric acid.

The data were analyzed by analysis of variance and student t-test according to the procedure of Snedecor and Cochran.

**Results**

Table 2 shows the chemical compositions and energy contents of *Sasa nipponica* foliage. The DM content of *Sasa nipponica* foliage during non-snowy periods in winter was significantly higher than those in summer and during snowy periods in winter. The experimental paddocks had various size, shape and topography. Vegetation in all paddocks mainly consisted of deciduous broadleaved trees and *Sasa nipponica* growing under the trees. The characteristics of each experimental paddock and total number of horses used for experiments are shown in Table 1. The age of the mares and fillies were 51 to 224 and 15 to 21 months of age, and their initial body weight were 330 to 406 and 205 to 260 kg, respectively. The mares had not delivered in that year when each experiment was carried out, and did not have any suckling foals during experimental periods. The dry matter weight of *Sasa nipponica* foliage on each paddock were enough to be ingested by the horses at the amount of 4% of their body weight.
The CP content of Sasa nipponica foliage during non-snowy periods in winter was significantly lower than that in summer (P<0.05). The NDF content of Sasa nipponica foliage during non-snowy periods in winter was significantly lower than those in summer and during snowy periods in winter (P<0.05).

Table 3 shows DM intake of Sasa nipponica foliage by mares and fillies. The DM intake by mares during snowy periods in winter was lower than that in summer (P<0.05), and that by fillies during snowy periods in winter was lower than that during non-snowy periods in winter (P<0.05). As well as expressing as a percent of their body weight, the DM intake of Sasa nipponica foliage during periods in winter was lower than that in summer in mares, and than those in summer and during non-snowy periods in winter in fillies (P<0.05).

Table 4 shows apparent digestibility of nutrients and energy in Sasa nipponica foliage. As digestibility in mares and fillies were similar, apparent digestibility were expressed as mean values for mares and fillies. Furthermore, digestibility in winter were expressed as mean values, as digestibility during non-snowy periods in winter and snowy periods in winter were similar. Although the digestibility of DM, OM and GE in summer and winter were similar, the digestibility of CP and EE were found to be significantly higher in winter than those in summer (P<0.05), and the digestibility of NDF in winter was lower than that in summer (P<0.05).

Table 5 shows digestible crude protein (DCP) and digestible energy (DE) contents of Sasa nipponica foliage. Both of the DCP and DE contents in winter were slightly lower than those in summer, but there were not significant difference.

Table 6 shows DCP and DE intake by mares and fillies. The DCP intake by mares during non-snowy and snowy periods in winter were similar to that in summer, however that by the fillies during non-snowy and snowy periods in winter were found to be significantly lower compared to that in summer (P<
The DE intake by mares during non-snowy periods in winter was similar to that in summer, while during snowy periods in winter, that was lower than in summer ($P<0.05$). The DE intake by fillies during snowy periods in winter was similar to that in summer and during non-snowy periods in winter.

Table 7 shows proportion of DCP and DE intake to the maintenance requirements (NRC, 1989) and body weight change of mares and fillies throughout the experimental period. The proportion of DCP intake to the maintenance requirement in mares and fillies was more than 100% in all seasons. The proportion of DE intake to the maintenance requirement in mares were more than 100% in summer and during non-snowy periods in winter, while that was 85% during snowy periods in winter resulting into their body weight loss during these experimental periods. The proportion of DE intake to the maintenance requirement in fillies were more than 100% in all seasons. The body weight gain of the fillies were found in summer and during non-snowy periods in winter, and their body weight maintained even during snowy periods in winter.

Discussion

We reported in the previous study that the digestibility between mature and yearling Hokkaido native horses, determined in individual feeding pens of *Sasa nipponica* foliage, fresh grass or grass hay, were similar. As well as in the present study, the digestibility of nutrients and energy in *Sasa nipponica* foliage between mares and fillies were found to be similar. These results agree with the results of Aiken et al. on horses fed Coastal Bermuda grass hay. The fillies, including yearling horses, would be similar to the mares in their digestion ability to constituents in roughage as well as under grazing conditions.

The CP and EE digestibility in winter were higher than those in summer during this study. During cold winter period, animals need more heat to maintain their body temperature thus require increased nutrients. The efficiency of CP and EE utilization as a source of heat energy may increase in a cold environment, and may have caused an increase in the digestibility. The difference of intake levels and quantity of exercise of the horses, which normally take place under grazing conditions, may have also affected digestibility.

The digestibility of NDF in winter was lower than that in summer, although the NDF content of *Sasa nipponica* foliage in winter was lower than that in summer. Ohara reported the crude fiber content of *Sasa senanensis* foliage was almost the same in winter and in summer but the digestibility in winter was less than half that in summer, and the increase of lignin content in winter might have affected the digestibility of crude fiber. The lignin contents in winter could be increased even in *Sasa nipponica* foliage and may have affected the digestibility of NDF.

The DCP and DE contents of *Sasa nipponica* foliage were found to be similar between summer and winter. On the other hand, the DM and DE intake of *Sasa nipponica* foliage during snowy periods in winter were relatively low, so the body weight of mares decreased. Salter and Hudson reported that feral horses had to graze with pawing at more than 20 cm of the snow depth. In the present study, it was observed that a snow layer of more than 40 cm depth restrained the grazing behavior of horses. It is considered that the body weight loss of mares during snowy periods in winter is caused by relatively low intake of *Sasa nipponica* foliage.

The grazing in winter is effective to sustain the vegetation of *Sasa nipponica*, because the nutrient for regrowth on the following year is stored in rhizome and winter-buds are formed in autumn. The utilization of *Sasa nipponica* foliage for grazing during snowy periods in winter is also effective, since fallen snow inhibits the grazing behavior and intake in animals and *Sasa nipponica* was left under the snow as well as after grazing.

The grazing system during snowy periods in winter is considered to be much more effective to sustain the utilization of *Sasa nipponica* on woodland. *Sasa nipponica* was considered to be useful for feeding Hokkaido native horses in winter, including during snowy winter, because of the steady nutrient value of *Sasa nipponica* foliage observed from summer to winter.

References

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Hokkaido native horses. J. Equine Sci. 6, 121-125.


* In Japanese with English summary.

** In Japanese only. Translated title by the present author.

*** In Japanese only. Translated title by the author.

要 旨

河合正人・福葉弘之*・近藤誠司*・秦 宽*・大久保正彦* (1996)：
夏季および冬季林間放牧地における北海道和種馬のミヤコササ（Sasa nipponica）摂取量、消化率、栄養価の比較。畜産誌 45, 15-19. 北海道農業大学農業管理学科 (060-8555 北海道帯広市福田町) *
北海道大学農学部 (060-8589 北海道札幌市北区)

林間放牧地における北海道和種馬のミヤコササ（Sasa nipponica）摂取量および消化率、栄養価を二重指示物質法 (double-indicator method) により測定し、夏季、非積雪冬季および積雪冬季の季節間で比較した。試験に用いた成雄馬および育成雄馬の頭数は、夏季に9および3頭、非積雪冬季に4および8頭、積雪冬季に4および6頭であった。検体採取量は、夏季および非積雪冬季において積雪冬期よりも多かった (P<0.05)。冬季におけるNDF消化率は、夏季より低かった (P<0.05)。冬季におけるDCPおよびDE含量は9.2% DMおよび1.73 Mcal/kg DMであり、夏季と程度であった。すべての季節において、成雄馬および育成雄馬のDCP摂取量はNRC（1989）の維持要求量を上回っていた。積雪冬季における成雄馬のDE摂取量は維持要求量を下回ており、体重は減少した。育成馬のDE摂取量はすべての季節において維持要求量を上回っており、体重および非積雪冬季には体重が増加し、積雪冬季においても体重は維持した。

キーワード：栄養価、摂取量、消化率、北海道和種馬、ミヤコササ、林間放牧地,