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Effects of Dietary Protein Level on Dry Matter Intake, and Production and Chemical Composition of Velvet Antler in Spotted Deer Fed Forest By-product Silage*

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ABSTRACT : The aim of this study was to provide basic information to allow improved nutritional management for velvet production by investigating the effects of dietary protein levels on dry matter intake and production and chemical composition of velvet antler in spotted deer (*Cervus nippon*). Twenty-four spotted deer stags were assigned to 4 unreplicated groups, Control (15% CP in diet, higher dry matter), CP10 (10% CP), CP15 (15% CP) and CP20 (20% CP). The velvet antlers were harvested from each stag on the 55th day after casting of the buttons from the previous set, measured for their size and weight, and the chemical composition of each antler was determined in three sections (top, middle, and base). Dry matter (DMI) and crude protein (CPI) intake were highest ($p<0.05$) for the Control and increased progressively ($p<0.05$) with increasing dietary protein level. Although not significant, mean length and girth of the main antler beam tended to be larger in either left or right beam with increasing protein level in the diet, longest in CP20 and shortest in CP10. Velvet antler production was lowest in CP10 and highest in CP20, which differed significantly ($p<0.05$). Only negligible differences were found between groups in chemical composition. It is concluded that dietary protein clearly influenced dry matter intake and velvet antler production, whereas there was comparatively little effect of dietary protein on chemical composition of antler in spotted deer. (**Key Words :** Chemical Composition, Dietary Protein Level, Dry Matter Intake, Spotted Deer, Velvet Antler Production)

INTRODUCTION

Deer have greatly been valued for many years as a source of velvet antler and therefore, they have mainly been farmed for velvet antler production in oriental countries. Velvet antlers have widely used for oriental medicine in Korea and other oriental countries (Fennessy, 1989) and are major sources of revenue for deer farmers. With increasing demand for velvet antler, deer farming is becoming a rapid growing industry as an alternative industry of animal husbandry in many part of world, including Korea, North America, and New Zealand (Sim, 1987). Thus, there is high concern for improvement of productivity and quality of velvet antler in deer farming industry and much research has done on relationship between velvet antler production and nutritional condition. Low quality feed, especially low dietary protein, is associated with small antlers in red deer (Geist, 1986) and Murphy and Coates (1966) suggested that low protein content in food may account for low productivity and sub optimal growth of velvet antler. Furthermore, many researchers reported that high protein level in diet promoted greatly antler growth in deer. French et al. (1956) noted that high performance in velvet antler growth attained at the high content of dietary protein and McEwen et al. (1957) argued that a 16.9% protein diet resulted in best antler growth when compared to lower protein diet. McEwen et al. (1957) reported that there was greatest skeletal growth and antler development in deer fed a diet with 17% crude protein and Liang et al. (1993) suggested that optimal production of velvet antler could be obtained with 22-23% of dietary protein. Therefore, cervids appear to be varied considerably in their response to diet as well as seasonal timing of nutritional supplementation (Ullrey, 1983; Muir and Sykes, 1988; Pearse and Fennessy, 1991; Fennessy, 1995; Jeon et al., 2003). However, limited information is available concerning the effect of dietary protein on the productivity and quality of velvet antler in spotted deer. This study was designed to determine the

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Table 1. Formulation of experimental diets

Feed	Treatment[1]			
	Control	CP10	CP15	CP20
	% of fresh matter			
Forest by-product silage	-	80	60	50
Lupin seed	20	-	15	40
Alfalfa bale	10	-	20	5
Oak leaf hay	55	10	-	-
Concentrate	15	10	5	5

[1] Control: 15% crude protein content in feed, CP10: 10% crude protein content in feed, CP15: 15% crude protein content in feed, CP20: 20% crude protein content in feed.

effects of dietary protein levels on dry matter intake, and production and chemical composition of velvet antler in spotted deer (*Cervus nippon*).

MATERIALS AND METHODS

The feeding trial took place between 1 March and 25 July 2003, at HANA Deer Research Institute, Chungju, Chungchongbuk province, Korea. Twenty-four stags of spotted deer aged 5-6 years old were used in trial. These stags were assigned to 4 unreplicated groups by production record of the previous year (2002). Experimental deer were housed in large opened fencing pens (7×9 m, each pen) with free access to water and commercial mineral block.

All deer received experimental diets above 3.0% of initial body weight (dry matter basis) with equal meals at 09:00 and 18:00 h. Deer in first group (Control) (avg. 89.1 kg initial body weight) were fed a diet adjusted to about 15% crude protein with oak leaf hay, lupin seed, alfalfa bale and concentrate as shown in Table 1. Deer (avg. 93.9 kg initial body weight) in second group (CP10) were fed a diet adjusted to about 10% crude protein with forest by-product silage, oak leaf hay and concentrate as shown in Table 1. Forest by-product silage was contained fresh leaves (about 67.5% of dry matter) and stems (about 32.5% of dry matter) of trees, shrubs and wild grasses collected in a reforestation area in August, 2002 and ensiled with a little hydration (adjustment with total moisture content of 65%) for fermentation after chopping with length of 2.7±2.3 cm. Silage had a fermentative quality of 4.1 pH and 8.9% lactic acid (DM basis). Deer (avg. 87.4 kg and 90.4 kg initial body weight) in third (CP15) and fourth (CP20) group were fed diets adjusted to about 15% and 20% crude protein with formulation as shown in Table 1, respectively. Body weights for experimental stags were determined at the beginning and end of experiment

Dry matter intake of each group was weekly estimated by subtracting refusals from the diet offered. The velvet antlers were harvested from experimental stags on 55th day after casting of the buttons from the previous set. Antlers were harvested from each stag under general anesthesia by a veterinarian, and each antler was immediately weighed by digital balance and measured by a tape measure for length and girth of the main beam. Removed each antler was also divided into three sections (top, middle, and base) of the main beam and was placed in freezer. Samples of each section were sliced with bone slicer, freeze-dried and stored at -40°C until analyzed.

Crude protein, crude fiber, ether extract, and crude ash for antler samples and experimental diets were determined by the method of the Association of Official Analytical Chemists (1990). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) of experimental diets were analyzed according to Georing and Van Soest (1970).

All data were expressed as means and statistically

Table 2. Chemical composition of experimental diets

Treatment[1]	Chemical composition[2]							
	DM	CP	EE	CF	Ash	NFE	NDF	ADF
	% of dry matter							
Control	81.0	15.1	4.5	29.7	6.2	44.5	46.4	28.0
CP10	44.6	9.6	2.7	49.5	4.1	34.1	64.9	47.4
CP15	56.1	14.9	2.7	43.5	4.2	34.7	59.3	41.9
CP20	63.6	19.2	3.5	36.4	3.4	37.5	52.3	34.1

[1] See Table 1 on the details.
[2] DM: dry matter, CP: crude protein, EE: ether extract, CF: crude fiber, Ash: crude ash, NFE: nitrogen free extract, NDF: neutral detergent fiber, ADF: acid detergent fiber.

Table 3. Mean (±SEM) dry matter (DMI) and crude protein (CPI) intake and daily gain (DG) in spotted deer fed diets of different protein level

Item	Treatment[1]			
	Control	CP10	CP15	CP20
DMI (g/day)	2,484.0±81.5[a]	2,069.2±13.0[b]	2,116.5±36.4[b]	2,395.7±16.8[a]
CPI (g/day)	862.5±166.8[a]	555.0±93.3[b]	719.7±213.3[ab]	902.5±131.1[a]
DG (g/day)	120.0±62.0[a]	52.5±34.0[b]	55.0±14.0[b]	130.0±28.0

[1] See Table 1 on the details.
[a, b] Within a same row, means not sharing a common superscript letter are not significantly different at $p<0.05$.

Table 4. Mean (±SEM) length and girth of main beam of antler in spotted deer fed diets of different protein level

Item	Part	Treatment[1]			
		Control	CP10	CP15	CP20
Length	Left	24.6±2.0	23.3±2.5	25.5±6.4	26.9±5.9
(cm)	Right	24.5±1.2	24.6±2.5	23.6±6.4	26.5±4.7
Girth	Top	14.6±0.5	12.6±0.2	16.1±2.4	15.4±2.6
(cm)	Middle	12.5±1.4	10.6±0.6	11.4±0.9	11.7±1.2
	Base	16.5±1.2[a]	14.2±0.7[ab]	12.3±1.6[b]	14.4±2.6[ab]

[1] See Table 1 on the details.

[a, b] Within a same row, means not sharing a common superscript letter are not significantly different at $p<0.05$.

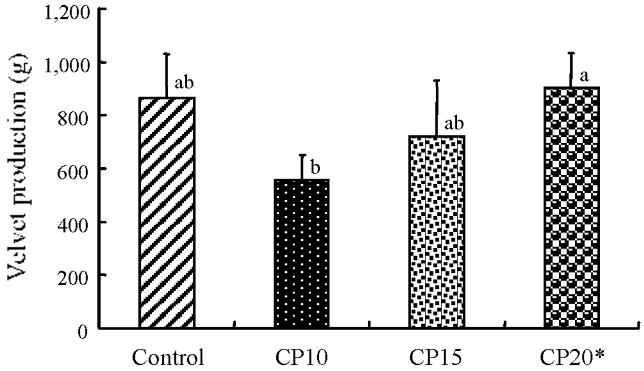

Figure 1. Mean (±SEM) antler production in deer fed diets of different protein level. * See Table 1 on the details. [a, b] Between bars, means not sharing a common superscript letter are not significantly different at $p<0.05$.

analyzed by analysis of variance (completely randomized design) and Duncan's multiple range test using SAS package (1995).

RESULTS AND DISCUSSION

Table 3 presents mean dry matter (DMI) and crude protein (CPI) intake and daily gain (DG) of spotted deer for the four different groups. Dry matter intake was highest ($p<0.05$) for Control and that was increased with increasing the protein level in diet. There were significant differences ($p<0.05$) in DMI according to increase of protein level in diet, although there was no significant difference between CP 10 and CP 15. Obtained results for CPI was similar to that for DMI. It seems to be more influence of dry matter content rather than protein level in feed for DMI and CPI which resulted in higher intake in Control than in CP15 despite similar level of protein. Therefore, DMI and CPI were likely related with dry matter and fiber content as mentioned in Table 2, a well-known factor limiting intake of ruminants (Forbes and Jacson, 1971; Okamoto, 1974; Forbes, 1986). Also CPI was closely related with not only protein content but also dry matter content. The quality of feed is one of the factors effecting intake of animal, however, physical characteristic of feed seems to be more influential factor.

Mean length of main beam and girth at part of base of harvested antler are given in Table 4. Although not significant, mean length of main beam tended to be longer in either left or right beam with increasing the protein level, longest in CP20 and shortest in CP10. In girth at part of base of main beam, it was a similar pattern to the result of length with the exception of girth in Control, showing the larger girth than CP15 which was same content of protein in diet. Jeon et al. (2003) analyzed that the protein level of diet had no effects on the length or girth of antler however, there was close relationship ($p<0.01$) between the length and girth of antler and the antler production in red deer. Also there were several studies that inferior nutritional condition during the antler growth resulted in small size of antler and low trophy quality (French et al., 1956; Cowan and Long, 1962; Blaxter et al., 1974; Hyvarinen et al., 1977). Therefore, although the effect of the protein level in diet was no significant on the size of antler, the protein level of diet seemed to be influential on dry matter intake and as a result antler size and production were also affected by the protein level of diet in this trial. On the other hand, there was a report that antler size had great individual difference and also there was no difference for antler size under the condition of relatively good nutrition (Muir et al., 1987).

Velvet antler production in spotted deer fed diets of different protein level is shown in Figure 1. It was clear trend to increase with increasing the protein level in diet. Velvet production was lowest in CP10 for 555.0±3.4 g and highest in CP20 for 902.5±131.2 g and there was significant difference ($p<0.05$) between CP10 and CP20. Antlers are bony structure, resembling other part of the skeleton in their mineral composition. Those start to grow during spring to summer, harden during autumn and remain dead and inert until they are cast in the following spring as new growth commences (Chapman, 1975). Especially, due to higher concentration of nutrient such as protein in antler tissues during the antler growth (Kay and Staines, 1981), it is believed to be increased the requirement of nutrient to meet optimal antler growth. Antler growth can affected by several factors such as genetic and environmental condition but under the same condition, it is thought to be influenced greatly by nutritional factor (French et al., 1956; Blaxter et al., 1974; Haigh and Hudson, 1993). Fennessy and Suttie

Table 5. Chemical composition by section of velvet antler in spotted deer fed diet of different protein level

Diet*	Velvet section	Chemical composition**				
		CP	EE	CF	Ash	NFE
Control	Top	71.9±0.3	4.8±1.5	1.2±0.5	19.6±2.2	2.5±0.4
	Middle	62.5±3.0	3.5±0.1	0.9±0.3	33.0±1.6	0.1±0.2
	Base	57.4±3.1	2.6±0.3	1.4±0.5	38.4±2.5	0.2±0.1
CP10	Top	74.1±2.7	5.3±1.4	2.0±0.5	14.4±2.3	4.2±0.5
	Middle	59.2±6.2	3.6±0.9	1.7±0.2	33.9±4.7	1.6±0.3
	Base	53.7±4.3	2.5±0.7	2.1±0.4	37.8±5.1	3.9±0.6
CP15	Top	67.7±3.3	4.7±0.5	1.7±0.5	17.7±2.6	8.2±1.7
	Middle	60.2±5.8	3.6±0.5	1.5±0.3	34.1±3.8	0.6±0.5
	Base	54.0±2.7	2.9±0.8	1.5±0.5	41.2±1.5	0.4±0.5
CP20	Top	68.3±5.3	4.3±0.6	1.3±0.4	21.6±2.6	4.5±1.2
	Middle	59.3±1.8	3.2±0.9	2.1±0.6	34.8±2.1	0.6±0.4
	Base	54.2±2.4	2.3±0.6	2.1±0.3	41.3±1.6	0.1±0.1

NS: not significant between treatments.
* See Table 1 on the details.
** CP: crude protein, EE: ether extract, CF: crude fiber, Ash: crude ash, NFE: nitrogen free extract.

(1985) pointed out that it is necessary improved nutritional management for deer to lead genetic potential for maximum antler growth, thus antler production is directly influenced by nutritional management for deer. Especially, because the protein level of diet during the antler growth period influences greatly on antler production (French et al., 1956; McEwen et al., 1957; Liang et al., 1993; Suttie et al., 1996), it has been suggested that it is most important thing to maintain proper level of protein in diet. Deer has been supplemented by conserved forages or grain based supplementary feeds to maximize their antler growth for required cases in deer farming industry of New Zealand which had velvet antler production system based on the intensive use of pasture to minimize cost (Suttie et al., 1996) and it has known to be targeted by protein levels of 25% during the antler growth period (Pearse et al., 2000).

In this experiment, it was analyzed that velvet production was largely influenced by the protein level of diet and thus it would be available to increase protein level of diet during the antler growth period to improve velvet productivity. Also it is assumed to be required the protein level of at least above 15 to near 20% in diet to improve velvet production. Some researchers reported that it is necessary about 17% of protein in white-tailed deer (McEwen et al., 1957) and about 20 to 23% of protein in spotted deer (Liang et al., 1993) to increase velvet antler production and therefore, it is thought to be proper protein level at around 17% for optimal antler growth. On the other hand, because there were some reports that underfeeding during any period, especially late autumn prost-rut body weight recovery period, reduced antler production in the subsequent spring (Muir and Skyes, 1988; Fennessy, 1989; Pearse et al., 2000), it will be needed more detail investigations.

Results of analysis of chemical composition for velvet antler produced in spotted deer fed experimental diet of different protein level are summarized in Table 5. Only negligible differences were found between groups in chemical composition. And despite different dietary protein level, the contents of crude protein and ether extract were highest in top section, and decreased downward in all groups. In contrast, the content of ash was lowest in top section, and increased downward with significant difference ($p<0.05$). There was a little information available concerning chemical composition of velvet antler in cervids. A limited number of studies have been worked on chemical composition of velvet antler of some species of cervids. Velvet antler was composed mostly by protein (Ullrey, 1983; Sunwoo, 1995) as shown in Table 5 and thus it is assumed to be essential providing protein to promote antler growth. In this experiment, dietary protein level influenced on antler growth (Figure 1), however, that was little influential on chemical composition of velvet antler. Chemical composition was no differences despite different dietary protein level and was varied only by the section of antler in this study. That is, quantitative variations were observed in chemical composition among the section of antler and this means that chemical composition of velvet antler appeared to be influenced by mineralization of antler rather than dietary protein level. Also it was found that chemical composition was within reference range that is increased or decreased downward (Sunwoo, 1995; Lee et al., 2003). On the other hand, essential amino acid and saturated and unsaturated fatty acid contents were 24.5, 40.2 and 55.1 in control, 25.1, 41.0 and 54.3 in CP10, 24.7, 41.4 and 55.4 in CP15 and 25.6, 40.8 and 55.7 in CP20, respectively and there were no significant differences between groups.

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