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Research Article

Determination of Protein Requirements for Maintenance of Elk Doe

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ABSTRACT

Data on the crude protein requirements of elk doe are nonexistent and the data are essential for their management in Korea. Therefore, this study was conducted to evaluate the crude protein requirement for maintenance of elk doe. Three female elk deer were used in 3 × 3 Latin square design with three diets containing three levels of crude protein (CP) that contained low crude protein (approximately 12%), medium crude protein (15%), and high crude protein (18%). Each three elk doe trials included a 14-day preliminary period and a 5-day collection period. Crude protein intake was 4.83, 6.26, and 9.00 g/d for 12%, 15%, and 18% of CP level, respectively. Crude protein balances were 1.04, 1.41, and 4.14 for 12%, 15%, and 18% of CP level, respectively. The maintenance requirement for CP from the regression equation between CP intake and CP balance were 3.70 g/$BW^{0.75}$.

(**Key words**: Elk Doe, Crude protein requirements, Maintenance)

Ⅰ. Introduction

Korea is the world's largest importer and consumer of deer velvet antler; however, domestic deer numbers have been decreasing by over 75% in the last 10 years. Recently, the Korean velvet antler self-sufficiency rate has been stagnant at ~ 20.2% (MAFDA, 2015). In 2018, approximately 1,700 Korean farms were rearing nearly 26,000 deer. The main species reared in these farms are sika deer (*Cervus nippon*), red deer (*Cervus elaphus*), and elk (*Cervus canadensis*), with elks constituting 46% of the rearing deer population in Korea (MIFAFF, 2018).

Deer rearing is an important part of Korea's livestock production; yet, there is a lack of research on systematic feeding standards. To set livestock feeding standards, the requirements of nutrients by the livestock growth stage are needed. Protein requirement depends on the gender, age, season, growth stage, body composition, species, and environmental conditions. To determine the protein and energy requirements, we need to conduct experiments regarding the nutrients required by livestock for maintenance of basic life phenomena and production. There have been several studies determining the protein requirements for maintenance of deer health (Tomkins and McMeniman, 2006; Smith et al., 1975; Holter et al., 1979; Mould and Robbins, 1981; Silva et al., 2003; Luo et al., 2004; Kim et al., 2006); however, research conducted on Korean elk doe is unavailable. Therefore, this research was conducted to estimate the protein requirements for maintenance of Korean elk doe.

Ⅱ. Materials and Methods

1. Experimental design

In this study, three breeding elk does with an average body weight of 277.4 ± 31.6 kg were randomly allocated diets with three levels of protein content according to a 3 x 3 Latin square experimental design to estimate the protein requirements for maintenance in breeding elk doe.

The composition of experimental diet is shown in Table 1. Does were fed 600 g/kg timothy hay and 400 g/kg corn-based concentrate which differed in crude protein (CP) concentrations; 12.0 (low CP), 15.0% (medium CP), and 18.0% (high CP) based on dry matter, respectively. Does were fed 2.2% of their average weight once daily at 9 am. Does had free access to water and

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Table 1. Ingredients and chemical compositions of experimental diets (%, DM basis)

Item	Dietary protein level			Roughage
	12%	15%	18%	
Ingredient				
Corn grain	34.87	35.16	35.28	
Soybean meal	2.69	10.00	16.00	
Coconut meal	10.00	10.00	15.00	
Rapessed meal	2.50	2.50	3.00	
Palm kernel meal	5.00	5.00	0.00	
Dried distiller's grains with solubles	6.50	3.50	9.00	
Wheat bran	15.00	10.40	2.00	
Corn gluten feed	15.00	15.00	13.08	
Soybean hulls	2.00	2.00	1.00	
Molasses	3.50	3.50	3.50	
Salt	1.20	1.20	0.50	
Limestone	1.50	1.50	1.40	
Mono-dicalcium phosphate	0.20	0.20	0.20	
Choline chloride	0.04	0.04	0.04	
Chemical composition				
Dry matter	87.80±0.12	87.30±0.66	88.30±0.14	86.50±0.19
Crude protein	16.0±0.03	19.8±0.20	24.9±0.10	6.9±0.27
Ether extract	2.75±0.05	3.96±0.34	3.32±0.02	0.99±0.24
Crude ash	6.5±0.05	5.8±0.68	6.7±0.12	4.3±0.13
Crude fiber	7.65±0.83	8.07±0.74	7.52±0.40	36.69±0.90
Neutral detergent fiber	30.63±0.70	30.53±1.00	36.26±1.50	66.33±0.62
Acid detergent fiber	10.42±0.60	9.94±0.77	9.89±0.93	40.62±0.38

mineral blocks such as rincal blocks for water, calcium, and phosphorus intake. To prevent any unnecessary stress and subsequent consequences, custom metabolism crates (3 x 6 m) for the elk feeding experiment were constructed and elks under study were observed closely for signs of stress during the adjustment periods. After an adjustment period of 30 days in the metabolism crate, there was an adjustment period of two weeks to the experimental feed for each treatment. For each period, complete manure samples were collected for 5 days after the adjustment period.

2. Analysis of feed and excrement samples

Experimental feed and excrements were collected and analyzed using a normal compositional analysis. When collecting urine samples, 300 ml of 4 N sulfuric acid was added to the urine sample containers every morning to prevent the volatilization of ammonium nitrate. After measuring the daily urine volume, a 10% of the urine sample was collected and stored in the freezer. Urine was collected for 5 days and mixed before being used as a sample for analysis. After daily fecal output was quantified, samples were stirred in a mixer for 20 minutes and a 10% of the feces was collected and stored in the freezer. This process was repeated for 5 days for each treatment. The final fecal collection was defrosted and mixed, and a sample was collected, dried for 48 hours at 60℃ in a forced-air oven, and analyzed for composition. Composition analysis was based on methods described by AOAC (1990).

3. Statistical Analysis

In this study, a general linear model was used to perform analysis of variance to verify the significance of our experimental data using SAS software (ver. 9.4, SAS Institute, Cary, NC, USA).

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A Duncan's multiple range test (1955) was used to analyze the averages of the experimental groups, and the level of significance was set at 5% ($p < 0.05$). Regression analysis was performed using the SAS REG procedure, which utilized the quantity of protein intake and protein balance to analyze the protein requirements for maintenance.

Ⅲ. Results and Discussion

Because data on the crude protein requirements of elk are insufficient in Korea, estimates of nitrogen requirements have been derived from studies of deer, even though digestive and metabolic capabilities can vary among species. In addition, even their data of deer are insufficient in Korea. Therefore, knowledge of elk nutritional requirements is essential for their management in Korea, because specific knowledge of elk requirements and the efficiencies of dietary use are necessary to avoid possibly misleading or inaccurate evaluations when using extrapolations from other species.

Table 2 shows the crude protein balance with different dietary protein levels. The protein intake ratio increased linearly with dietary protein level ($p < 0.05$). There was no significant difference between the treatment groups with respect to protein quantity in manure; however, quantity of protein excreted tended to increase with increased protein intake. The relationship between protein uptake and protein balance per metabolic body size was shown in Fig. 1. The equation determined from the regression analysis was $Y = 0.7326X - 2.7092$ (r-square = 0.8262, $p < 0.01$), and the x-intercept, which is the protein requirement for maintenance, was 3.70 g/BW$^{0.75}$ when protein balance is zero.

To determine the protein and energy requirements, we need to conduct experiments regarding the requirements of nutrients ingested by livestock for maintenance of basic life phenomena and production (Nam et al., 2011). Factorial, nitrogen, and feeding trial methods are used to determine protein requirement for maintenance. To measure the protein requirement for maintenance using the factorial method, we require the amount of nitrogen and metabolic protein excreted through manure, skin, and so on; however, this method tends to result in relatively high values being measured. Furthermore, the feeding trial method, which is based on the growth of the animal, needs a relatively large study sample size. Additionally, the changes in body composition and weight during the growth process and pregnancy can be problematic (Nam et al., 2011; Yang et al., 2014).

The protein requirement for maintenance of breeding elk presented by NRC (2007) is 201 g/d when the weight is 235 kg, and the requirement per metabolic body size is 3.35 g/kg BW$^{0.75}$(Table 3). However, these results are from research on North American elks, and differences with this research result may be due to species differences and environmental linfluences, as species respond differently to different environments.

Protein is a macromolecule composed of amino acids linked by peptide bonds; it produces peptides or amino acids when hydrolyzed by the digestive enzymes in the body. Proteins are a major component of the body that comprise 80% of the components

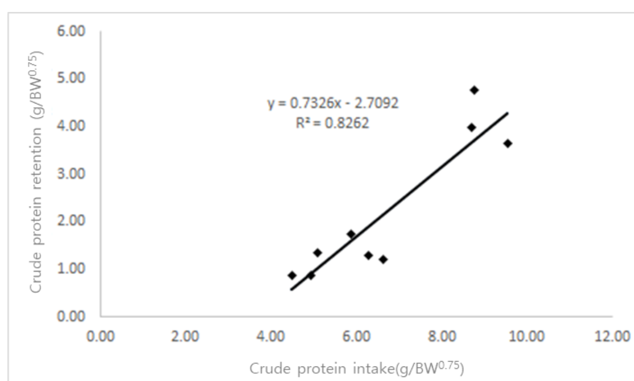

Fig. 1. Regression equation of retained crude protein according crude protein intake by elk doe.

Table 2. Crude protein balance of elk doe feed diets with different levels of crude protein

Item	Dietary protein level		
	12%	15%	18%
Intake (g/d)	4.83±0.31[c]	6.26±0.37[b]	9.00±0.47[a]
Excretion (g/d)	3.78±0.23	4.85±0.66	4.86±0.97
Retention (g/d)	1.04±0.28[c]	1.41±0.29[b]	4.14±0.57[a]

[a,b,c] Means with different letters within the same row differ (p<0.05).

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Table 3. Metabolizable protein requirements of small ruminants for pregnancy deer (NRC, 2007)

Item	Body weigh (kg)	Metabolizable protein (g/d)	Metabolizable protein (g/kg $BW^{0.75}$)
white-tailed deer	50	88	4.66
red deer	80	106	3.96
elk/wapiti	235	201	3.35

remaining after excluding water and fat in every tissue in an animal body. In addition, proteins play an important role in biological production and life phenomena like muscular movement, enzymatic and hormonal effects, and immune responses. Furthermore, proteins are actively accumulated in a growing animal, which results in an increase in protein requirement, and protein deficiency can inhibit or stop growth. Thus, protein is particularly important for growing animals and it is reported that a large quantity of protein is consumed during antler development (Price and Allen, 2004; Goss, 1983).

There were various difficulties in conducting the experiment and data analysis to determine the protein requirements (NRC, 2007). It was especially difficult to determine whether the increase in protein level is caused by the increase in metabolic protein or the increase in net energy because energy increases as the amount of protein feed increases. It was also challenging to distinguish between rumen degradable protein and rumen undegradable protein in the effects of metabolic protein. This means that only study animals weighing 100–300 kg can be used even for weight gain experiments (NRC, 2007). Therefore, we used elk with an average weight of ~300 kg as study animals.

However, to set exact feeding standards such as the protein requirement, protein requirement for weight gain and other information are needed. Protein requirements for maintenance can be determined through current research, but protein deposits of weight gain of elks fed in Korea need to be measured in the future to determine more accurate protein requirements and feeding standards. Primarily, it seems that we need to set the protein requirements and feeding standards based on the value presented by NRC (2007), and then compare this to determine the protein requirements and feeding standards of elk via actual feeding.

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