

# Progress on nutritional requirements of deer farmed for velvet production in China

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## Abstract

Research in China has shown a marked variation in the energy and protein requirements of sika deer (*Cervus nippon*) for velvet antler production as the stag grows. Information includes energy and protein requirements for male sika deer throughout their life and pregnant and lactating females. Estimates of energy utilization and methane production are also included. Protein requirements during early growth and development of the stag are high, while they decline as the stag ages. Protein requirements during velvet antler growth are higher than during other times of year. The maintenance energy requirements of the male sika deer of 0.52 MJME/kgBW<sup>0.75</sup> are similar to those estimated for red deer. The Chinese system of reporting gross energy, digestible energy and digestible protein requirements has been converted into metabolisable energy requirements and diet protein concentrations for the New Zealand feeding system to aid interpretation.

**Keywords:** *Cervus nippon*, deer, energy, feed requirements, methane, protein, sika, velvet antler

## Introduction

Deer are animals which have very high economic value. Deer farming in China can be traced back 300 years. Chinese farm deer mainly to produce velvet antler. Velvet antler is a valuable traditional medicine that is widely used in most Asian countries. The species of deer used for velvet production in China are sika deer (*Cervus nippon*) and wapiti (*C. elaphus*).

In recent years, due to high economic returns from velvet antler and deer co-products, deer farming has been rapidly expanding not only in China and some Asian countries, but also in non-traditional countries, like New Zealand, Australia and Canada.

Today, world deer farming has become a developed industry. In order to meet the demand of this fast expanding industry, a series of studies has been carried out on how to make use of available feed sources rationally, reduce feed costs and fully satisfy the needs of antler-producing stags for a variety of nutrients.

Data for the nutritional requirements of velvet antler production is summarized here from Chinese research. It is a comprehensive series of investigations into the changing requirements of the male sika deer from

weaning until maturity and adds significantly to what is known in New Zealand. However, the Chinese and New Zealand systems for describing energy and protein requirements are different. Care should be taken to distinguish between these systems and that the feeding levels are not directly transferred to New Zealand situations without proper interpretation. Some attempt has been made to aid that interpretation in Table 1, and the final section of the paper.

## Deer farming in China

Deer farms were initially located in the natural habitat of the sika and wapiti deer in the northeast of China. In recent years, with the increase in demand for velvet antler as a traditional medicine, deer farms have been built up all over China, spreading from the northeast. Recent statistics report that China now has at least 1.1 million farmed deer, up from 500,000 in the early 1990's. Dried velvet antler production is around 500 tons per annum (approximately 1500 t green weight).

The two main species of farmed deer in China are sika deer and wapiti, though China is home to at least a dozen deer species. Currently, sika deer accounts for 84% of the deer population, wapiti accounts for 13%, and the rest of the deer species constitute 3%.

The Chinese farm deer in feed lots rather than at pasture due to the pressure on land for other uses. Diets are made up of concentrates with supplementary roughage in the form of leaves, branches and cut forage.

## Energy Metabolism

Recent studies have established the metabolic requirements for sika deer. Gao *et al.* (1996a) conducted feeding trials, digestion trials and respiratory heat measurement tests to investigate energy metabolism for adult male deer (mature size of 120-140 kg). Results indicated that fasting heat production requirements were 365 KJ/kgW<sup>0.75</sup> and metabolisable energy for maintenance was 516 KJ/kgW<sup>0.75</sup>, with energy being used with an efficiency of 0.707 for maintenance. Gao *et al.* (1996a) also carried out heat of respiration trials and digestion-metabolism trials at different feeding levels using 4 male deer. Results showed that energy digestibility, metabolic rate, heat production and body energy retention were all raised when gross energy intake

increased. Energy reserves might be deposited with efficiencies of 0.59 and 0.61 for protein and fat, respectively.

The metabolic production of methane energy (CH<sub>4</sub>E) of sika deer was studied using indirect respiration calorimetry and digestion-metabolism trials in adult male sika deer (Li *et al.* 1996). Results showed that the amount of CH<sub>4</sub>E produced from sika deer was raised as feed intake increased and fell with the lapse of time after feeding. The amount of CH<sub>4</sub>E produced was 6.6 %, 8.8 % and 10.9 % of gross energy intake (GEI), digestible energy intake and retained energy, respectively. In addition, CH<sub>4</sub>E production was decreased following improvement of the dietary protein level. When the dietary protein level was increased by 1 %, the amounts of CH<sub>4</sub>E production was reduced by 58.6 kJ per day. The relationships between CH<sub>4</sub>E and gross energy intake and dry matter intake (DMI) were expressed by the following equations:

$$\text{CH}_4\text{E (kJ/d)} = 0.07 \text{ GEI (kJ/d)} - 101.04$$

$$\text{CH}_4\text{E (kJ/d)} = 98.78 + 1.05 \text{ DMI (g/d)}$$

### Optimal Dietary Nutritional Levels and Requirements

#### Post-weaning period (body weight of 30-60 kg)

Wang *et al.* (1996) studied the effects of different energy and protein levels on young deer after weaning. Results indicated that the optimal gross energy (GE) and protein (CP) levels in concentrated feed were 17.2-18.0 MJ/kg and 28 % respectively. Total daily digestible crude protein (DCP) requirement was 219-232 g/d and digestible energy (DE) requirement was 23.4-24.6 MJ/d (Gao *et al.* 1996).

#### Growth Stage (body weight of 60-100 kg)

Gao *et al.* (1997) showed that live weight gains of the yearling sika deer were significantly influenced by the interaction between dietary energy and protein. The apparent digestibility of crude protein was increased following the increase in dietary protein level. The optimal dietary energy and crude protein concentrations were 17.4 MJ GE/kg and 22.4% CP respectively. The daily requirements of energy and protein per deer were 28.5-28.9 MJ DE/d and 400-410 g DCP/d respectively during the antler growth period for yearling sika deer. Gao & Wang (1996) investigated the effects of dietary protein and energy levels on weight gain for yearling sika deer in winter. Results indicated that the optimal protein level was 18% CP, energy concentration was 16.3 MJ GE/kg in the supplemental concentrate, and the daily requirements of protein and energy per deer were 150 g DCP and 23.1 MJ DE respectively.

Gao *et al.* (1993) studied the effects of different levels of dietary protein and energy on the velvet antler yield and weight during the antler growth period for two-

year-old male sika deer. The results indicated that the intakes of crude protein and digestible crude protein per day were significantly influenced by dietary protein level. The CP and DCP intakes were higher for the groups receiving 21% CP than for those receiving 18% CP. There was no significant difference between the different groups in velvet antler yield. The live weight gains of the group fed 21% CP were numerically higher than those fed 18% CP, but there were no statistically significant differences between them. The energy level had no significant effects on the velvet antler yield and weight gain. These did not increase with the increased energy concentration in the diets. The results of these experiments demonstrated that the optimal crude protein, energy concentration and protein-energy ratio were 18.5-19.5% CP, 16.5-17.0 MJ GE/kg and 12-13 g/MJ respectively. The total daily requirements of digestible crude protein and digestible energy were 315 g DCP/d and 27.2-29.9 MJ DE/d respectively.

Gao *et al.* (1995) measured the energy and protein requirements in feeding and digestion trials for two-year-old deer in winter. They suggested that DE requirement was 36.9 MJ/d and DCP requirement was 194 g/d.

There has been little research conducted on the mineral nutrition of deer. Wang *et al.* (1997) conducted a study to investigate the effects of dietary Ca and P levels on antler growth using 3-year-old sika deer. Results showed that the optimal Ca and P levels in the diet were 0.89% and 0.52% respectively. Ca and P levels in the diet had effects on Ca contents in antler serum at the antler-harvesting stage, but no effects on P contents.

#### Adult male Sika Deer (mature body weight of 100-140kg)

In the past ten years, Jin and Gao *et al.* have investigated the protein and energy requirements for adult sika deer (over four years old) in feeding and digestion trials. Results showed that the optimal dietary energy concentration and crude protein levels were 16.7-17.2 MJ GE/kg and 16 to 18% CP respectively. The total daily requirements of digestible crude protein and digestible energy were 330-360 g DCP/d and 38.1-39.8 MJ DE/d respectively during the antler growth period. In winter, the total daily protein requirement was 200-230 g DCP/d and the energy requirement was 33.1-37.7 MJ DE/d.

#### Adult female Sika Deer (mature body weight of 80-95 kg)

A few studies have been undertaken to estimate the optimal dietary energy concentration and crude protein level for female sika deer during different physiological periods using feeding and digestion trials (Gao *et al.* 1996b).

Results during gestation showed that the optimal energy concentration and crude protein level in

**Table 1** The conversion of digestible energy and digestible crude protein requirements into metabolisable energy and crude protein requirements for New Zealand pasture feeding conditions, based on a conversion of digestible energy to metabolisable energy of 0.81 for pastures (AFRC 1993) and a pasture protein digestibility of 0.75 (van Soest 1994).

Stock class	Period	Animal weight	Energy requirements			Intake			Protein requirements		
			MJDE/d <sup>1</sup>	MJME/d <sup>2</sup>	kg DM/d <sup>3</sup>	DCP/d <sup>4</sup>	gCP/kgDM <sup>5</sup>	gCP/kgDM <sup>6</sup>			
Calf	Post-weaning	30-60 kg	24	19.4	1.9	225	280	160			
Male	Yearling	Winter	23	18.6	1.8	150	180	110			
		Antler growing	28.7	23.2	2.2	405	224	245			
	2-3 year old	Winter	36.9	29.9	2.8	194	190	90			
		Antler growing	28.5	23.1	2.2	315	190	190			
	Mature	Winter	35.4	28.7	2.7	215	170	105			
		Antler growing	39	31.6	3.0	345	170	155			
Female	Early pregnancy	80-95 kg	14.3	11.6	1.1	90	166	110			
	Late pregnancy		14.4	11.7	1.1	145	203	175			
	Lactation		25	20.3	1.9	205	236	145			

<sup>1</sup> Digestible energy requirements from the text.

<sup>2</sup> Metabolisable energy requirement = MJDE \* 0.81.

<sup>3</sup> Intake assuming pasture of 10.5 MJME/kg.

<sup>4</sup> Digestible crude protein requirements from the text.

<sup>5</sup> Crude protein requirements of reported Chinese diets from the text.

<sup>6</sup> Crude protein requirements assuming a digestibility of 0.75 for pasture.

concentrated feed were 16.7 MJ GE/kg and 16.6% CP respectively in mid pregnancy. The optimal energy concentration and crude protein level in concentrated feed were 17.1 MJ GE/kg and 20.3% CP respectively during late pregnancy. The daily requirements of digestible energy and digestible crude protein per deer were 14.4 MJ DE/d and 85-90 g DCP/d respectively during mid pregnancy. The daily requirements of digestible energy and digestible crude protein during late pregnancy were 14.4 MJ DE/d and 140-145 g DCP/d respectively for female sika deer.

Feeding and digestion trials were conducted with female sika deer during lactation. The results showed that dietary energy concentration had significant effects on the suckling calf body weight gain, protein digestibility and energy digestibility ( $P < 0.01$ ). The optimal energy concentration and crude protein level in concentrated feed were 17.6 MJ GE/kg and 23.6% CP respectively. The daily requirements of digestible energy and digestible crude protein per deer were 24-25 MJ DE/d and 200-210 g DCP/d respectively during the lactation period for female sika deer (Gao *et al.* 2001).

The requirements of dietary crude protein for female wapiti (Chinese Malu) were determined in digestion and metabolism experiments. The appropriate levels of dietary crude protein for the gestation and lactation periods were approximately 10% and 15% CP respectively (Li *et al.* 2000).

### Implications for New Zealand farming systems

Experiences with feeding in China can be made relevant to New Zealand deer farming through the conversion of the requirements outlined in the text to the New Zealand forage system. The New Zealand system is based on metabolisable energy (ME). Table 1 converts the text values for digestible energy (DE) requirements to metabolisable energy requirements using a generalized relationship of ME/DE of 0.81 (AFRC 1993). Dry matter intake is then calculated based on an energy concentration in pasture of 10.5 MJME/kgDM.

Daily digestible crude protein requirements from the text have also been converted into dietary crude protein concentrations based on the daily feed intake and a general digestibility of crude protein in pasture of 75% (van Soest 1994). Of interest is the high protein requirement for stags during the early years of antler development. Research in New Zealand (Suttie unpub. data) showed small increases in antler weight and significant increases in antler quality associated with high protein supplements.

The estimated New Zealand dietary CP concentrations are at times different from the dietary protein concentrations of the Chinese diets (Table 1). Generally the predicted dietary protein concentrations for deer grazing New Zealand pastures are lower than those suggested by the Chinese research. This may be due to the different species of deer or the feeds available.

Diets formulated in China rely on byproducts from human food industries, as well as supplementation using forages of many sources. The New Zealand pasture diet is relatively constant by comparison. An illustration of the complexity of Chinese diets comes from the number of feeds available. Yang *et al.* (1994) conducted nutritional composition analysis for 110 kinds of feedstuff and reported the values for the dry matter, energy, crude protein, crude lipids, crude fibre, nitrogen free extracts and crude ash of the different kinds of feed. These feeds included concentrates (loose mix of cereal grains), meals (feed cakes made from the residue after oilseed extraction), sorghum and wheat bran (seed coats left after flour extraction), dry tree leaves, fresh grass, by-products from agriculture, by-products from industries, and animal derived feed. Li *et al.* (1996) analysed the nutritional composition of 42 kinds of tree leaves and 51 fresh grasses using multiple-cluster statistical methods and found that tree leaves could be divided into 3 to 4 categories; fresh grasses could be divided into 7 categories.

These feeds vary widely in digestibility. Jin *et al.* (1994) measured the degradation rate for dry matter, protein, and organic matter of corn, fresh oak tree leaves, corn silage, wheat bran, soybean cake and soybean residue. Gao *et al.* (1996) measured the degradation rate for dry matter, protein, and organic matter for 73 kinds of deer feed. Degradation rates of 0.0339/h, 0.0266/h, 0.0244/h and 0.0213/h for soybean cake, corn powder, oak leaves and corn silage were measured respectively when their particle size was approximately 0.25 – 0.50 mm.

Dried and processed feeds also vary significantly in the digestibility of protein while the protein in fresh pasture has a very high digestibility (van Soest 1994). This has significant impacts on the crude protein concentrations needed in the diet to meet animal requirements.

## Conclusions

Research in China has provided a wealth of nutrition information to help advance the Chinese velvet antler industry. Lessons from the Chinese research in diet formulation and protein requirements may provide some

future direction for the improvement of the New Zealand velvet antler industry when interpreted and tested in New Zealand conditions.

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