Effect of Salt Level in the Feed on Performance of Red and Fallow Weaner Deer

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ABSTRACT : In Australia, many cropping areas are affected by salt. In these regions, Chenopodiaceous plants, such as *Atriplex, Kochia* and *Bassia spp* have been planted to improve soil conditions. These plants have become invaluable feed resources for grazing animals in dry summers, but have a high sodium content. To assess the impact of high salt intake on grazing deer, two experiments were conducted. The first experiment used 30 fallow weaner deer to examine the effect of salt level in the diet on feed intake, water intake and body weight of fallow deer. Salt was added to lucerne chaff at 0, 1.5, 3.0, 4.5 and 6% and fresh water was offered all the time. Increasing the salt level in the diet from 0 to 6% didn't affect feed intake, osmotic pressure and mineral concentration in blood of fallow deer. However, water intake was significantly higher ($p<0.05$) in deer fed diets containing more than 3% salt. Body weight was lower ($p\leq0.056$) for fallow deer in July and August when salt content was over 3%, suggesting they can ingest over 15 g sodium/day without significant depression in both feed intake and growth rate if the fresh water is available. In the second experiment, 18 red weaner deer were fed lucerne chaff diets containing 1.5, 4.5 and 6.0% salt with 6 deer/diet. The results revealed that feed intake and blood osmotic pressure were similar ($p>0.05$) for red deer fed different levels of salt although the feed intake declined from 1.91 to 1.67 kg with the increase of salt level from 1.5% to 6.0% in the diet. Water intake was significantly higher for deer fed diets containing over 4.5% salt, but there was no difference in body weight during the experiment. However, no recommendation can be made on the salt tolerance of red deer due to limited increment of salt level in the diet. ***(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 5 : 638-642)***

Key Words : Feed Intake, Body Weight, Water Intake, Salt Tolerance

INTRODUCTION

Sodium is one of the main macro minerals required by animals and plays an important role in the acid-balance and osmotic regulation of the body fluids. Under grazing conditions, animals can generally obtain sufficient amount of sodium from water, pastures, soils and other mineral supplements. However it is difficult to quantify the intake of sodium under grazing conditions because sodium intake of grazing animals is often influenced by environmental conditions, pasture management and animal factors. In Australia, many cropping areas are affected by salt. In these regions, Chenopodiaceous plants, such as *Atriplex, Kochia* and *Bassia spp* have been planted to improve soil conditions (Sharma, 1978; Wilson, 1978; Leigh, 1986). These plants supply forage during drought periods for grazing animals (Sharma, 1978), but their leaves are extremely rich in salt (Wood, 1925; Mozafar and Goodin, 1970). It is known that these shrubs are very valuable in summer. The intake of A. *nummularia* (oldman saltbush) was sufficient to maintain sheep in summer and to allow a small weight gain. The bodyweight production per unit area was similar for sheep and cattle, but sheep selected more green grass than cattle which consumed more dry grass and saltbush (Wilson, 1966a). Proximate analyses of the leaves of these shrubs show that they are high in crude protein and ash during summer. However, the high ash content (30% of the dry matter) may be a disadvantage (Wilson, 1966a; Wilson 1978), as high salt intakes through ingestion of these shrubs by grazing could adversely influence electrolyte balance and cause water intoxication for grazing animals. The surplus Na^+ increases the blood osmotic pressure which induces the grazing animals to consume more water to maintain electrolyte balance. While the deer industry has been successfully developed in these shrubs growing regions, the potential impact of excessive salt intake on deer production is unknown. The salt tolerance has been well defined for sheep, cattle and other livestock species, but the variation between animal species, breeds within species, maturity status and grazing environments makes it impossible to apply these values directly to deer. To optimise deer production and effectively use natural resources, it is essential to understand the salt tolerance of deer at different physiological stages and the effect of excessive salt intake on growth and reproduction of grazing deer. The objective of this study was to examine the effect of salt level in feed on feed intake and growth rate of fallow and red deer.

MATERIALS AND METHODS

Paddocks

Ten paddocks of 900 m^2 were fenced with 2 m high wire. Each paddock had a water trough (100 L) and feeder

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Table 1. Mineral content (ppm) of the experimental diets based on pure lucerne chaff fed to fallow and red deer

Dietary salt level (%)	Ca	Mg	Na	K
0.0	12,300	3,200	3,200	24,000
1.5	12,700	3,200	9,900	24,000
3.0	13,300	3,300	16,000	24,000
4.5	12,500	3,100	21,000	24,000
6.0	11,500	3,000	26,000	22,000

(200 L). The water trough was connected to a 200 L tank, raised 1.5 m above ground to allow gravity filling of the water trough. The water tank was calibrated by the manufacturer to a 0.5 L accuracy. Water troughs and feeders were covered on the top with corrugated iron 1 m above ground level to stop rainwater dropping into the drinking water and feed. In June, the paddocks were sprayed with a mixture of Roundup® and Goal® to remove all growing plant materials.

Animals and management

The experiments were run from April 18 to August 1, 2002 on Roseworthy Campus, 60 km north of Adelaide and 10 km east of Gawler in South Australia. Thirty fallow weaners were selected from Roseworthy Deer Farm and divided into five groups (6 deer/group) based on body weight. The deer were fed on pure lucerne chaff for 3 weeks before introducing the experimental diets. From week 4, the five groups of fallow deer were fed on lucerne chaff with added salt content of 0, 1.5, 3.0, 4.5 and 6.0%, respectively. Mineral content of the five diets is listed in Table 1. At the end of the trial, two deer from each of the 0 and 6% salt treatments were slaughtered. Liver, muscle, lung, kidney and heart were sampled and freeze dried. Water content in the organs was measured using a freeze drier.

For the experiment with red deer, 18 red calves were divided into three groups (6 deer/group) based on their body weight and fed on pure lucerne chaff for 3 weeks before feeding experimental diets. From week 4, the three groups of red deer were fed on lucerne chaff with added salt content of 1.5, 3.0 and 6.0%, respectively. Mineral content of these diets is listed in Table 1.

Measurement

Feed and water intake : During the experimental period, deer were monitored daily for any abnormal behaviour and to ensure that feed was available all the time. Feed residues were collected weekly to measure feed intake. The water levels in the tank were read daily for estimating water intake. The rainfall was measured during the trial and corrected for the water intake calculation based on the surface area of the water troughs.

Blood sampling : Blood samples were taken at the end of the trials using Vacutainer tubes. Deer were restrained in the crush and a blood sample was taken from the vein in the neck of the animal. Samples were immediately placed on ice. Once sampling had been completed, blood tubes were returned to the laboratory to spin in a centrifuge for 10 minutes at 3,000 rpm. Serum was extracted from the tubes and analysed for osmotic pressure and mineral content.

Bodyweight : Animals were fasted overnight and weighed every three weeks to monitor bodyweight changes.

Analysis

Minerals in the feed, animal tissue and blood samples were analysed using an inductively coupled plasma (ICP) analyser (Zarcinas et al., 1987). Osmotic pressure was measured using a Micro-Osmometer (model 3 MO plus).

Statistics

The experiments were an unrepeated randomised design. The 10 paddocks were located in the same area with an identical microenvironment. The individual animals were used as replicates for data analysis. The main factor of these experiments was salt level in the diet. Anova from the Systat program (Wilkinson et al., 1992) was used to assess the effect of salt level in feed on performance of deer.

RESULTS

For fallow weaner deer, there was no difference in feed intake, water intake, body weight, blood osmotic pressure and blood mineral concentration prior to feeding salt diets. The experimental diets contained 0.32, 0.99, 1.6, 2.1 and

Table 2. Feed intake, water intake and mineral content in blood of fallow deer fed different levels of salt in the pelleted diet based on pure lucerne chaff

	Salt level					Stats	
	0	1.5	3	4.5	6	P value	SEM
Feed intake (kg/day)	0.945	0.948	0.972	0.890	0.834	0.439	0.057
Water intake (L/day)	1.557[b]	1.58[b]	2.698[a]	2.943[a]	3.387[a]	0.001	0.250
Osmotic pressure (Mosm)	299.5	301.2	301.8	303.7	304.0	0.487	1.964
Minerals in blood (ppm)							
Ca	104.4	108.5	109.3	106.8	107.3	0.610	2.264
Mg	18.7	19.7	18.1	17.8	19.5	0.052	0.506
Na	3,283.3	3,300.0	3,333.3	3,300.0	3,300.0	0.839	30.732
K	209.1	227.8	235.2	246.7	241.7	0.290	12.765

[a, b] Values followed with different letters within a row were different between treatments at p<0.05, SEM; standard error of means.

Table 3. Body weight changes (kg) of fallow deer fed on different levels of salt in the pelleted diet based on pure lucerne chaff

Date	Salt level					Stats	
	0	1.5	3	4.5	6	P value	SEM
May 10*	25.7	26.9	27.3	25.0	26.1	0.089	0.594
May 29*	27.3	29.4	29.0	27.0	27.5	0.121	0.746
June 20	27.9	29.7	29.3	27.6	28.0	0.279	0.765
July 11	27.8^{ab}	29.5^{a}	28.5^{ab}	25.8^{b}	26.9^{ab}	0.007	0.656
July 31	27.7	29.8	28.5	26.6	27.5	0.056	0.707
Aug 1*	26.8^{ab}	28.8^{a}	27.7^{ab}	25.8^{b}	26.7^{ab}	0.046	0.661

* Bodyweight after fasted for 24 h, [a, b] Values followed with different letters within a row were different between treatments at p<0.05.
SEM; standard error of means.

Table 4. Feed intake, water intake and mineral content in blood of red deer fed different levels of salt in the pelleted diet based on pure lucerne chaff

	Salt level			Stats	
	1.5	4.5	6	P value	SEM
Feed intake (kg/day)	1.910	1.841	1.669	0.293	0.110
Water intake (L/day)	2.733^{b}	4.789^{a}	4.776^{a}	0.008	0.509
Osmotic pressure (Mosm)	311.3	306.4	301.6	0.060	2.446
Minerals in blood (ppm)					
Ca	110.0^{ab}	112.1^{b}	107.5^{a}	0.036	1.133
Mg	19.3	17.5	18.0	0.073	0.520
Na	$3,383.3^{a}$	$3,300.0^{ab}$	$3,216.7^{b}$	0.004	29.187
K	268.3	260.0	276.7	0.450	9.078

[a, b] Values followed with different letters within a row were different between treatments at p<0.05, SEM; standard error of means.

Table 5. Body weight changes (kg) of red deer fed on different levels of salt in the pelleted diet based on pure lucerne chaff

Date	Salt level			Stats	
	1.5	4.5	6	P value	SEM
May 10*	50.9	51.2	51.1	0.998	3.21
May 29*	56.1	56.7	56.7	0.991	3.439
June 20	55.4	56.0	55.0	0.971	3.105
July 11	54.5	51.9	54.1	0.808	3.135
July 31	54.5	53.9	54.1	0.990	2.903
Aug 1*	52.8	51.8	52.3	0.972	2.867

* Body weight after 24 h fasting, SEM; standard error of means.

2.6% of Na at the salt inclusion levels of 0, 1.5, 3.0, 4.5 and 6.0%, respectively. The Ca, Mg and K contents were similar for all experimental diets (Table 1). Adding 6% salt in the lucerne chaff did not affect feed intake, blood osmotic pressure and blood mineral concentration in fallow deer (p>0.05), but water intake was significantly higher (p<0.05) for deer fed diets containing over 3% salt (Table 2). The water intake per kg dry matter intake ranged 1.65-4.06 L with the increase of sodium in the diet from 0.32 to 2.6%. Body weight in July and August was lower when salt content was over 3% (Table 3). No difference was found in dressing percentage, water content and mineral concentration of liver, lung, kidney and muscle of deer fed 0% and 6% salt in the diet although a limited number of deer were slaughtered (2 from each group).

For red weaner deer, there was no difference (p>0.05) in feed intake, water intake, body weight, blood osmotic pressure and blood mineral concentration prior to feeding salty diets. Feed intake and blood osmotic pressure were similar (p>0.05) for deer fed different levels of salt (Table 4) although the feed intake declined from 1.91 to 1.67 kg with the increase of salt level from 1.5 to 6.0% in the diet. While there was no change in Mg and K concentration in blood, blood Na content tended to decline with increasing salt level in the diet. However, this did not result in any negative effect on performance. Water intake was significantly higher for deer fed diets containing over 4.5% salt (Table 4), but there was no difference in body weight during the experiment (Table 5).

DISCUSSION

During the experimental period, no abnormal behaviour and salt toxic symptoms were observed. However, the body weight of deer declined over the period between end of May and July. Previous studies conducted on this site also showed similar result, presumably due to the low temperature and poorer quality of feed available at this period of year (Ru and Glatz, 2002). While lucerne chaff had a higher quality than other herbages available at this time of the year, the digestible energy content of lucerne chaff was only about 10.3 MJ/kg on an air dry basis (Ru et al., 2002). The daily digestible energy intake was only about 9.7 MJ for fallow deer and 19.7 MJ for red deer in the lower salt treatment groups. The energy intake of fallow deer was only slightly higher than the maintenance requirement in June (8.22 MJ/day), but lower than the maintenance requirement in July (10.3 MJ/day) (Ru and Glatz, 2002). Similarly, the metabolisable energy intake of red deer on low salt level (16.2 MJ ME/day) was lower than the value (21 MJ ME/day) recommended by New Zealand researchers in winter (Fennessy et al., 1981), assuming the conversion ratio of digestible energy to metabolisable energy is 0.82.

Salt tolerance has been interpreted as the absence of a depression in the intake of a certain ration (Peirce, 1959). While deer can ingest salt from pastures, soils and water, the actual sodium intake from these sources in the current study is negligible and was similar for all treatment groups. However, fallow deer consumed 9.4, 15.6, 18.7 and 21.7 g sodium daily from lucerne chaff containing 1.5, 3.0, 4.5 and 6% salt, respectively, resulting in a significant increase in water intake, especially when salt content was over 3%. Feed intake declined by only 8% when salt level increased from 3 to 4.5%. Considering the changes in body weight, feed intake and water intake, it is obvious that fallow deer can tolerate 3% salt (1.6% sodium) in the diet. This clearly indicates that fallow deer can ingest over 15 g sodium/day without significant depression in both feed intake and growth rate if the fresh water is available. This result further demonstrated the key roles of fresh water in the regulation of sodium metabolism. However, when salt is ingested through drinking water, the absorption and excretion rate of sodium could differ from the sodium ingested from feed, encouraging the further assessment of the tolerance of deer to salt in drinking water.

Red deer responded differently to salt level in the diet compared to fallow deer in the current study. While the increment of salt level in the diet was larger for red deer than fallow deer due to the lack of red calves, the feed intake was not different between all treatments although a 9% decline in intake occurred when salt level increased from 4.5 to 6%. It is surprising that red deer did not show any difference in body weight between these treatments, especially when the deer were fasted for 24 h to reduce the amount of water retained in the gut. Whether the 24 h period is long enough for red deer to empty the water retained in the digestive tract is not clear and no data on the water content in the tissue were obtained for red deer in this study. If the salt tolerance is determined only based on feed intake and body weight gain, it can be concluded that red deer can be fed up to 6% of salt, equivalent to 2.6% sodium. However, the salt tolerance level for red deer should be examined more comprehensively before recommendations on high levels of salt intake can be made to the industry.

The current salt levels included in the diets were lower than those tested in sheep, making it difficult to directly compare the response to salt level by sheep and deer. The salt intake at the highest level in the current study were 50 g/day for fallow deer and 100 g/day for red deer, but Wilson (1966b) reported that sheep can ingest up to 97 g sodium/day when offered fresh water. Meyer and Weir (1954) also recorded an intake of 104 g sodium/day by sheep offered a pelleted ration containing 13.1% sodium chloride. The outcomes of the current study cannot answer whether deer are less tolerant than sheep, but performance of fallow deer may suggest that salt level over 3% will not be benefit to the fallow deer.

Chenopodiaceous plants, such as *Atriplex, Kochia* and *Bassia spp* are an important feed resource during drought periods for grazing animals in Australia because of their remarkable capacity to remain leafy and viable under high radiation and temperature levels (Sharma, 1978). However, the leaves of these shrubs have variable nutritional value. For examples, the ash content ranges 18.5-27.2% on a dry matter basis and sodium content ranges from 0.2-5.6% on a dry matter basis (Khalil et al., 1986). Wilson (1966b) also reported 8% sodium in saltbush leaves in summer. It is believed that high salt content of saltbush is detrimental to grazing animals, but the impact of grazing saltbush on animal production is dependent on the amount of saltbush in the diet. Under grazing conditions, the diet of grazing animals often contains a variable amount of saltbush due to the difference in availability of other alternative feeds such as grasses which are relatively low in sodium, but in dry periods the saltbush content often approaches 100% (Leigh and Mulham, 1967). More importantly, the availability of fresh water is a key factor influencing the responses of grazing animals to salty feed as shown in the current and early research. For example, sheep were fed on diets containing 7.5, 11.25 and 15% added sodium chloride to simulate diets containing up to 100% saltbush. When access to water was restricted to once daily, there was a reduction in food intake, reduction being more severe with the more salty water (Wilson and Hindley, 1968). The increased fresh water intake of deer fed on salty feed may help to excrete sodium through urine as Wilson (1966b) reported that 89-98% of the ingested sodium was excreted in the urine in sheep. However, no simple recommendation could be made for the utilisation of saltbush by grazing deer from this study because of the variable salt content of saltbushes and availability of fresh water.

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