

## Effect of Salt Level in Water on Feed Intake and Growth Rate of Red and Fallow Weaner Deer

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**ABSTRACT** : Under a typical Mediterranean environment in southern Australia, the evaporation rate increases significantly in hot summers, resulting in highly saline drinking water for grazing animals. Also in the cropping areas, dryland salinity is a problem. Grazing animals under these environments can ingest excessive amount of salt from feed, drinking water and soil, which can lead to a reduction in growth rate. To understand the impact of high salt intake on grazing deer, two experiments were conducted to assess the effect of salt levels in drinking water on feed intake and growth rate of red and fallow weaner deer. The results revealed that fallow deer did not show any abnormal behaviour or sickness when salt level in drinking water was increased from 0% to 2.5%. Feed intake was not affected until the salt content in water exceeded 1.5%. Body weight gain was not affected by 1.2% salt in drinking water, but was reduced as salt content in water increased. Compared with deer on fresh water, the feed intake of red deer on saline water was 11-13% lower when salt level in drinking water was 0.4-0.8%. An increase in salt level in water up to 1% resulted in about a 30% reduction in feed intake ( $p < 0.01$ ). Body weight gain was significantly ( $p = 0.004$ ) reduced when salt level reached 1.2%. The deer on 1% salt tended to have a higher ( $p = 0.052$ ) osmotic pressure in serum. The concentration of P, K, Mg and S in serum was affected when salt level in water was over 1.0%. The results suggested that the salt level in drinking water should be lower than 1.2% for fallow weaner deer and 0.8% for red weaner deer to avoid any reduction in feed intake. Deer farmers need to regularly test the salt levels in drinking water on their farms to ensure that the salt intake of grazing deer is not over the levels that deer can tolerate. (*Asian-Aust. J. Anim. Sci.* 2005, Vol 18, No. 1 : 32-37)

**Key Words** : Water Intake, Salt Tolerance, Salt Intake

### INTRODUCTION

It has been well documented that sodium is one of the key elements for grazing animals, but excessive intake of sodium could reduce feed intake and growth rate. This is particularly true in southern Australia where the temperature in summer can be over 40°C. Under this environment, the evaporation of water in dams and water troughs often result in a high salt concentration in the drinking water. In field situations, this can cause an increase of 10% in concentration of salts even though the troughs are cleaned regularly (Wilson, 1978). The risk of excessive salt intake is more significant in the salt affected regions where grazing animals rely on the pastures and bushes (e.g. saltbush) as a major nutrient supply in dry summers. As the deer industry expands in these regions, the assessment of the impact of excessive salt intake on deer production will assist deer farmers to establish their management strategies to achieve maximum profit.

In the previous experiments, the effect of salt level in feed on feed intake and growth rate was assessed for red and fallow weaner deer (Ru et al., 2004). The results revealed that 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 weaner deer, but deer

drank much more water when fed diets containing more than 3% salt. Feed intake and blood osmotic pressure were similar for red deer fed different levels of salt although the feed intake declined by 14% when the salt level increased from 1.5% to 6.0% in the diet. There was no difference in body weight during the experiment. In these experiments, fresh water was available *ad libitum*, which may assist deer to excrete the excessive salt. However, under field situations, water is one of major sources of salt for grazing animals and salt level in water could have more significant impact on their growth. Wilson (1978) reported that sheep can tolerate 1.5% of sodium chloride in their drinking water, and Peirce (1959) recommended 1.3% as a safe maximum concentration, although 2.0% could be tolerated (Wilson, 1966). Peirce (1957, 1962, 1966, 1968a,b) found that water containing 1.0-1.3% soluble salts reduced appetite and caused some deaths in adult sheep, and sometimes reduced the number of lambs born and their growth rate. However, due to the difference in salt tolerance between animal species, these figures might not apply to grazing deer. The following experiments were designed to assess the effect of salt concentration in drinking water on feed intake and growth rate of red and fallow weaner deer.

### MATERIALS AND METHODS

#### Paddocks

Four paddocks (900 m<sup>2</sup>) were fenced with 2 m high wire.

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**Table 1.** Mineral content in pellet feed and water for the fallow deer trial

	Ca	Mg	Na	K
	Feed (ppm)			
Pellet feed	12,550.0	2,350.0	1,885.0	13,550.0
	Water			
Salt level (%)				
0.0	40.0	20.0	105.0	<20
0.3	33.6	16.5	1,370.0	<20
0.6	34.7	16.3	2,500.0	<20
0.9	36.1	16.7	3,700.0	20.6
1.2	35.5	16.2	5,400.0	22.3
1.5	37.0	16.1	6,200.0	37.5
2.0	44.2	15.5	7,900.0	<20
2.5	41.9	17.0	9,500.0	<20

Each paddock had a water trough (100 L) and a feeder (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 be read at an accuracy of 0.5 L. Water troughs and feeders were covered with corrugated iron 1 m above ground level to stop rainwater falling into the drinking water and feed. In June, the paddocks were sprayed with a mixture of Roundup<sup>®</sup> and Goal<sup>®</sup> to remove all growing plant materials.

#### Animals and management

The experiments were conducted from April 18 to August 1, 2002 for fallow deer and from April 28 to July 18, 2003 for red deer on Roseworthy Campus, 60 km north of Adelaide and 10 km east of Gawler in South Australia. A total of 40 fallow weaners were divided into 4 groups based on body weight. The average weights for each group were 21.97, 21.53, 22.25 and 23.15 kg, respectively. Each group had 5 male and 5 female deer. Deer were housed in paddocks without any pasture and only fed commercial deer pellets for 2 weeks before introducing to experimental treatments. From week 3, two groups of fallow deer were fed on commercial deer pellets containing 17% crude protein and about 10 MJ metabolisable energy/kg and offered bore water, while the other two groups were offered salt water with concentration being increased every two weeks to 0.3, 0.6, 0.9, 1.2, 1.5, 2.0 and 2.5% respectively. Mineral content in feed and water with different salt contents is listed in Table 1.

For the red deer trial, a total of 20 red weaners were divided into 4 groups based on body weight. Each group consisted of 3 female and 2 male deer. The average weights for each group were 55.2, 55.2, 56.7 and 55.5 kg, respectively. Deer were housed in the same paddocks previously used for the fallow deer trial. There were no pastures in these paddocks and deer were only fed commercial deer pellets during the experiments. The commercial deer pellets contained 17% crude protein and

**Table 2.** Mineral concentration (ppm) in feed and water for the red deer trial

	Ca	Mg	Na	K
	Feed (ppm)			
Pellet feed	16,500.0	1,930.0	2,200.0	12,300.0
	Water			
Salt level (%)				
0.0	32.0	21.0	100.0	<20
0.4	35.0	21.0	1,850.0	<20
0.8	38.0	21.0	3,600.0	<20
1.0	32.0	20.0	4,800.0	<20
1.2	39.0	22.0	5,100.0	<20

about 10 MJ metabolisable energy/kg. After a 2 week introduction, two groups of red deer were fed on deer pellets and offered bore water, while the other two groups were offered salt water with concentration being increased every two weeks to 0.4, 0.8, 1.0 and 1.2%, respectively. Mineral content in feed and water with different salt contents is listed in Table 2.

#### Measurements

*Feed and water intake* : During the experimental period, deer were monitored daily for any abnormal behaviour and feed was available at all times. Feed residues were collected weekly to measure feed intake. The water levels in the tank were read daily to an 0.5 L accuracy for estimating water intake. The rainfall was measured during the trial and a correction for the water intake applied based on the surface area of the water trough.

*Blood sampling* : Blood samples were taken at the end of the trials using Vacutainer<sup>®</sup> tubes for fallow deer. However, blood samples were taken during the week when salt level in water was 1.0% for red deer when feed intake and body weight gain started declining. Deer were restrained in a crush and a blood sample (9 ml) was taken from the jugular vein. Samples were immediately placed on ice. Once sampling had been completed, blood tubes were returned to the laboratory and centrifuged for 10 minutes at 3,000 rpm. Serum was pipetted from the tubes and analysed for osmotic pressure and mineral content.

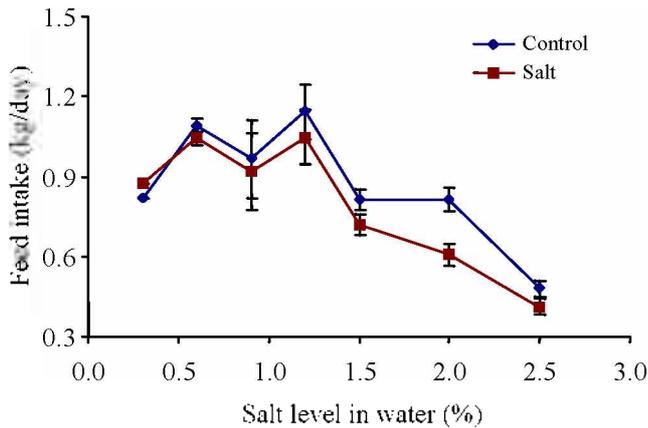
*Bodyweight* : Animals were fasted overnight and weighed fortnightly to monitor bodyweight changes, when salt levels were changed in the water.

#### Analysis

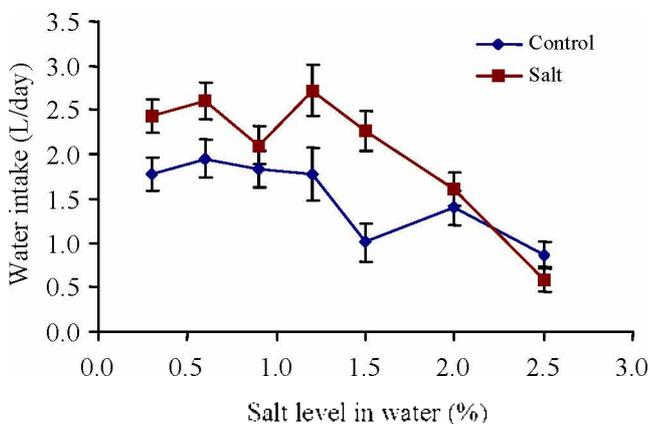
Minerals in the feed, animal tissue and blood samples were analysed using an inductively coupled plasma (ICP) analyser (Zarcinas et al., 1987). Osmotic pressure was measured using a Micro-Osmometer (model 3MO plus).

#### Statistics

The experiment was a randomised block design with two replicates per treatment. The four paddocks were



**Figure 1.** Feed intake of fallow weaner deer drinking water with different salt concentration.



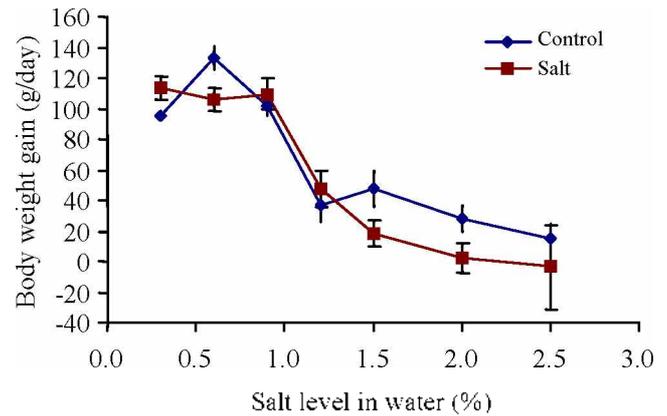
**Figure 2.** Water intake of fallow weaner deer provided drinking water with different salt concentration.

located in the same area with an identical microenvironment. The main factor in these experiments was salt level in the diet. The general linear model test from the Systat program (Wilkinson et al., 1992) was used to assess the effect of salt level in drinking water on performance of deer.

## RESULTS

### Fallow deer

No deer showed any abnormal behaviour or sickness during the trial. There was no difference in feed intake when salt concentration in water ranged from 0.3 to 1.2%. However, the feed intake was reduced significantly when salt content in water was greater than 1.5% (Figure 1). Adding salt in the water significantly increased water intake



**Figure 3.** Body weight gain of fallow weaner deer provided drinking water with different salt concentration.

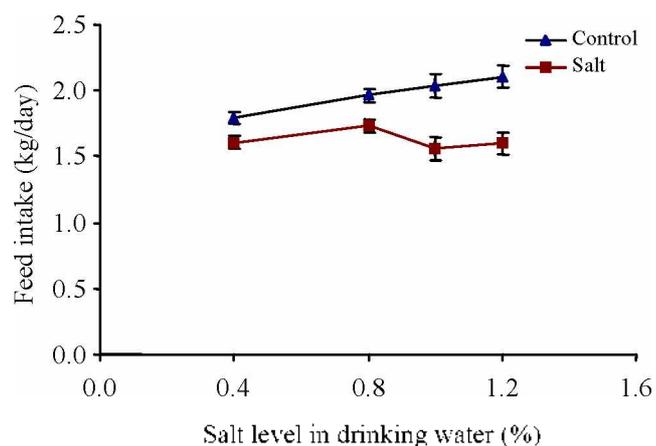
of fallow weaner deer. When salt level in water reached 2.5%, water intake was reduced (Figure 2). Body weight gain was not affected up to 1.2% salt in drinking water, but was reduced by further increases in salt content in water (Figure 3). There was no difference in osmotic pressure and mineral content in blood between deer drinking water with 2.5% or 0% added salt except for Mg. Deer drinking salty water (2.5%) had a lower Mg content in the blood than those drinking bore water (0% salt treatment) (Table 3).

### Red deer

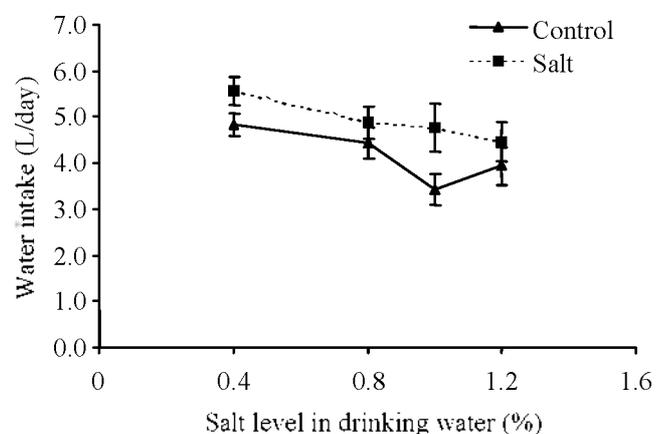
In the third week of the experiment, two deer from both the control and salt treatment groups escaped by jumping over the fence. These two deer were very sensitive and were excluded from the trial to ensure that other deer would not be disturbed. All deer were healthy and did not show any abnormal behaviour during the trial, but one deer was sick in the last week of the trial when the salt level in the water was 1.2%. Thus the experiment was terminated and the sick deer was euthanased. Samples of urine and blood were analysed for minerals. Kidney and liver samples were examined by a veterinarian. No significant changes or lesions were noted in the liver tissue. A moderate number of kidney tubules contained crystalline material that was consistent with oxalate crystals. Many of the convoluted tubules had also undergone degeneration (nephrosis) and the ducts in the medulla contained proteinaceous material, suggesting a mild oxalate poisoning. In grazing animals this is usually the result of eating plants such as Sour Sob, or one of the other oxalate containing plants. Even though the changes were mild, their effects may have been exacerbated

**Table 3.** Osmotic pressure and mineral content (ppm) in serum of fallow deer offered drinking water with 0 (Control) or 2.5% (Salt) salt content

Group	Osmotic pressure	Fe	Cu	Zn	Ca	Mg	Na	K	P	S
Control	303.0	5.5	0.9	0.7	101.5	18.0	3,335.0	231.0	103.9	1,013.5
Salt	303.1	5.2	0.9	0.7	101.2	16.8	3,330.0	223.8	98.8	1,003.5
SEM	1.30	0.89	0.02	0.02	0.71	0.32	9.79	4.81	2.72	6.71
P	0.96	0.81	0.26	0.34	0.72	0.01	0.72	0.30	0.20	0.30



**Figure 4.** Feed intake (kg/day/deer) of red weaner deer offered fresh water or water with different levels of salt in April-July 2003.

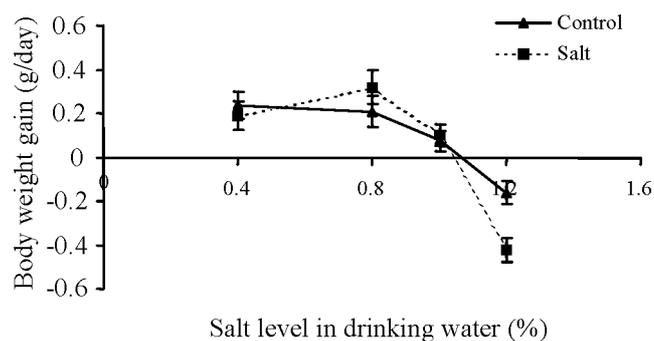


**Figure 5.** Daily water intake of red weaner deer offered fresh water or water with different levels of salt during April-July 2003.

by salty water. The sodium concentration was 4,400 ppm in urine and 3,500 ppm in blood, and osmotic pressure was 366 for urine and 318 for blood for this deer.

Compared with deer on fresh water, the feed intake of deer on salty water was 11-13% lower when salt level in drinking water was 0.4-0.8% ( $p>0.05$ ; Figure 4). An increase in salt level in water up to 1% resulted in about 30% reduction in feed intake ( $p<0.01$ ). Water intake was variable between treatment groups and days, depending on the weather. However, deer on salty water had a higher water intake than those on fresh water (Figure 5).

There was no significant difference ( $p>0.05$ ) in body



**Figure 6.** Body weight gain of red weaner deer offered fresh water or water with different levels of salt during April-July 2003.

weight between groups at the start of the trial and the body weight increased in the first 4 weeks for all groups when the salt level in water was 0.4-0.8%. However, the body weight declined rapidly during June and July for all groups and the rate of decline was significantly higher ( $p<0.05$ ) for the salt treatment group than the control (Figure 6).

The deer on 1% salt treatment tended to have a higher osmotic pressure in serum ( $p=0.052$ ; Table 4). The concentration of P and K in serum tended to be higher ( $p<0.1$ ) for deer drinking salty water. S concentration in serum was 75 ppm higher and Mg concentration was 2 ppm lower for deer on salty water than those on fresh water. However, there was no difference in the concentration of other minerals in serum ( $p>0.05$ ) between control and treatment groups (1% salt in drinking water).

## DISCUSSION

### Salt tolerance of red and fallow weaner deer

While no fallow deer showed any abnormal behaviour or sickness during the trial, the feed intake and body weight gain was reduced when the salt concentration in drinking water was 1.5%. Based on the fact that salt tolerance can be interpreted as the absence of a depression in the intake of a certain ration, it can be concluded that fallow deer can tolerate 1.2% salt in the drinking water, equivalent to 5,400 ppm sodium in water. The relationship between the depression of growth rate (X) and salt level (Y) in drinking water ( $Y=-0.0306X+1.2143$ ,  $R^2=0.65$ ,  $n=6$ ) also suggested that the salt level in the drinking water is 1.2% when the difference in body weight gain (X) between control and salt treatment groups is 0.

**Table 4.** Osmotic pressure and mineral concentration (ppm) in serum of red deer drinking fresh water (control) or water containing 1% salt (Salt)

Treatment	Osmotic pressure	Fe	Cu	Zn	Ca	Mg	Na	K	P	S
Control	291.0	53.6	0.5	0.7	97.0	22.1	3,112.5	473.8	97.5	1,121.3
Salt	300.9	116.0	0.6	0.7	93.5	20.3	3,037.5	681.3	114.3	1,196.3
SEM	3.36	28.05	0.09	0.06	2.47	0.38	84.91	77.97	6.49	23.96
P value	0.057	0.138	0.762	0.993	0.33	0.004	0.542	0.081	0.089	0.044

For red weaner deer, the feed intake was reduced by 10% when salt concentration was 0.8% and over 30% when salt concentration reached 1.0%. The reduction in feed intake was not reflected in body weight gain until the salt level in water reached 1.0%. If feed intake is used as an indicator for salt tolerance, the red deer can only tolerate 0.8%, equivalent to 3,600 ppm sodium in water. However, a sodium concentration in drinking water should not be over 4,800 ppm to avoid the reduction of growth rate of red weaner deer. This demonstrated the different responses to salty water by red and fallow deer. When converting the data into the daily salt intake per kg metabolisable liveweight ( $W^{0.75}$ ) basis, the difference between red and fallow deer was more significant (1.74 g/kg  $W^{0.75}$  for red deer vs. 2.70 g/kg  $W^{0.75}$  for fallow deer) although the total salt intake through drinking water were slightly higher for red deer than fallow deer (39 g/day vs. 33 g/day).

#### Difference between animal species

When comparing the data with those reported for sheep, it is clear that deer and sheep have different tolerance levels for salt. For example, based on the current study, the growth was depressed when drinking water contained over 1.2% and 1.0% salt for fallow and red deer, respectively, but Wilson (1978) reported that sheep can tolerate 1.5% of sodium chloride in their drinking water, and Peirce (1959) recommended 1.3% as a safe maximum concentration, although 2.0% could be tolerated (Wilson, 1966). Wilson (1978) also reported that saline water (about 1.5% of total salts) may not affect animal production subject to the environmental conditions, but over 2% total salt in the drinking water is detrimental to production and survival of sheep. These levels are much higher than the levels defined for red and fallow weaner deer in the current study even after considering the minor contribution of about 100 ppm from other minerals, including Fe, Mn, B, Cu, Mo, Co, Ni, Zn, Ca, Mg, K, P, S, Al and Cd. Thus deer producers need to be cautious when using the recommended level of salinity tolerance for livestock (Inglis, 1985) as their guideline.

It is obvious that salt intake level of grazing fallow deer was not reflected in Na concentration in blood. Similar results were reported with sheep. For example, Peirce (1957, 1962, 1966, 1968a, 1968b) found that water containing 1.0-1.3% soluble salts reduced appetite and caused some deaths in adult sheep, and sometimes reduced the number of lambs born and their growth rate, but saline water (1.3% NaCl) had no effect on the concentrations of sodium, potassium, calcium or chloride in the blood plasma (Peirce, 1959, 1963). Red deer showed differences in S and Mg concentrations in serum between control and treatment groups and tended to have a high osmotic pressure, including high P and K concentrations in serum when drinking water containing 1% salt. However, there is not

enough evidence to conclude that fallow deer have a better capability of maintaining the balance of minerals in serum than red deer.

#### Effect of environment conditions and feed resource on salt tolerance of deer

The results obtained from the current study can only be used as a guideline because the salinity tolerance of animals varies with environmental conditions, type of feed and stage of physiological development. Early research showed that sheep and cattle grazing greenfeed could tolerate higher concentrations of salt in water than the same stock on dry feed. Animals grazing on saltbush are less tolerant than those grazing other types of pastures (Inglis, 1985). Sheep have a higher tolerance to saline water when fed on lucerne chaff than on oaten chaff (Wilson and Dudzinski, 1973). Pregnant, lactating or young stock have decreased tolerance to saline water than dry mature stock (Inglis, 1985). It was also reported that ewes and lambs are less tolerant of saline water than the non-pregnant and older sheep, and older sheep or sheep with previous experience of saline water are more tolerant than young and unexperienced sheep (Peirce, 1968a,b; Wilson, 1975). Based on these facts, the outcomes of the current study cannot be extrapolated to adult deer.

It should also be pointed out that in this study, the tolerance level of red and fallow weaner deer to the saline water was estimated when deer were offered commercial pelleted feed with a sodium concentration of 0.2%. Salt intake through soil was not determined. Under field situations, grazing deer are always exposed to feed and soils containing high salt levels, especially in the salt-affected areas. In these areas, saltbush or other herbage with high sodium content are valuable feed for grazing deer. It was also recognised that animals cannot avoid ingesting soil during grazing. The amount of soil intake by grazing animals are dependent on stocking rate, pasture growth and the location of grain supplementation which could be dusty and muddy. For example, on short pastures, cattle could ingest over 100 g soil/kg herbage dry matter (Dewes, 1996) and sheep up to 300 g soil/kg herbage dry matter (Thornton, 1983). Therefore, the contribution of soil and salty feed resources to total salt intake of deer cannot be ignored under grazing conditions. In addition, the current research was conducted over April to July when the temperature is low in southern Australia, associated with a low water intake compared with that in dry and hot summers. The maximum salt level in drinking water that deer can tolerate may be lower in summers.

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