RURAL INDUSTRIES RESEARCH
& DEVELOPMENT CORPORATION

Salt Intake and Red and Fallow Deer:
A literature review

A report for the Rural Industries Research and Development Corporation

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Foreword

In the 2000/01 funding round, the Corporation has agreed to fund a project that looks at the tolerance of fallow and red deer to salt. Unfortunately salt is going to become an increasing problem for Australian agriculture and it will be important that there is some baseline information on how the deer industry operates in that context.

This project is being carried out by the South Australian Research and Development Institute and in their application, they submitted an extensive literature review. The Deer Research and Development Advisory Committee believed that this review should be published so that debate on this important subject can be facilitated.

This forthcoming project will be funded from industry revenue which is matched by funds provided by the Federal Government.

This report, a new addition to RIRDC's diverse range of over 500 research publications, forms part of our Deer R&D program, which aims to foster an Australian deer industry as a profitable and efficient mainstream agricultural enterprise.

Most of our publications are available for viewing, downloading or purchasing online through our website:

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Peter Core
Managing Director
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Executive Summary

Southern and south-western Australia are typical mediterranean environments, characterised by wet, cold winters and dry, hot summers. The evaporation rate varies significantly in summer, resulting in a high salinity of drinking water for grazing animals. In addition, a large amount of land in the cropping areas is affected by salt. Puccinellia, tall wheat grass and saltbushes have been planted to improve the soil condition and to supply feed for grazing animals. Animals grazing these areas often ingest an excessive amount of salt from soil, forage and drinking water which can reduce feed intake, increase the water requirement, depress growth and affect body composition as demonstrated in sheep.

While the deer industry has been successfully developed in these 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 status of grazing deer and the impact of excessive salt intake on growth and reproduction of deer.

1. Introduction

Sodium is one of the main macro minerals required by animals, and plays an important role in maintaining osmotic pressure, rumen pH and regulating the volume of fluid in the body (Xu *et al.* 1994). For optimum growth, reproduction and other physiological functions, adequate amounts of sodium need to be supplied through feeds, drinking water and other sources. NRC (1980) reported that minimum concentrations of sodium in the diet are 0.7-0.9 g/kg DM for sheep, and 0.8-1.2 g/kg DM for cattle, with a significant variation between animal species, breeds within species, and maturity status. There is no data available on the sodium requirement of grazing deer, which is a significant disadvantage for deer producers in Australia. Farmers require information on sodium requirement of deer and the effect of high sodium intake on deer production, especially in southern Australia.

This review was requested by the Deer Program Committee of RIRDC to accompany a full research submission on the effect of salt intake on deer production. The review will focus on i) the environmental conditions in cereal cropping areas and the distribution of red and fallow deer in Australia, and ii) sodium intake and its potential impact on deer production under these environments.

2. Objectives

This review focuses on the following

- Environmental conditions in cereal cropping areas and the distribution of red and fallow deer in Australia,
- Sodium intake and its potential impact on deer production under these environments.

3. Literature Review

Environment conditions in cereal cropping areas in Australia

Southern and south-western Australia is a typical Mediterranean environment. The annual rainfall in this area ranges from 200 mm to 1000 mm, with 85% of the rain falling in winter. The distribution of annual rainfall exhibits marked variation between years and locations (Bellotti *et al*. 1992). For example, Geraldton receives 80-85% of annual rainfall in the growing season, but Merredin, Clare, Walpeup and Horsham receive about 66%, 61%, 59% and 58% of the annual rainfall during the growing season respectively. The temperature ranges from 9 ^oC in winter to above 40 ^oC in summer. Mid-winter temperatures are mild (12-15^oC) and mid-winter radiation levels are low, ranging from 9 MJ/m^2.day to 11 MJ/m^2.day (Perry 1989). Evapotranspiration rates vary more in summer than in winter, contributing to the salinity problem in the cropping areas.

In the summer rainfall region, covering north-eastern region from central New South Wales to Queensland, rainfall is higher than in the south and increases in both amount and summer dominance to the north. For example, the average annual rainfall for Dubbo, Narrabri, Dalby, and Biloela are 531, 662, 614, and 705 mm, with 42%, 38%, 29% and 19% falling in the winter (May-October) growing season, respectively. Mid-winter day temperatures range 15-19 ^oC. South eastern Australia is a high rainfall zone, with a significant amount of rainfall in both summer and winter. Mid-winter temperatures are about 10-12 ^oC and radiation levels range from 7 MJ/m^2.day to 9 MJ/m^2.day (Perry 1989). However, the maximum temperatures in these regions can be over 40 ^oC, with 20-40 days per year having a maximum temperature over 35 ^oC (Anon 2000).

In the cropping region, there is a large amount of land with high salinity. In Western Australia in 1980, 263000 ha was salt-affected land with a further 2.45 million ha having the potential to become salt-affected (Henschke 1980; Anon 1988a). By 1989, 315000 ha was salt-affected (Malcolm 1989). Salinity also threatens 385 000 ha in Victoria (Anon 1989), and 2.2% of the state in New South Wales (Anon 1988c) and affected 210,900 ha in South Australia (Anon 1988b). Salt affected soils range from sands to clays and include all grades of soils. Except for the most acidic soils, all soils can grow *Puccinellia ciliata, Atriplex spp. Halosaarcia spp.* and *Maireana brevifolia* or combination of these species (Malcolm 1989). The Department of Agriculture Western Australia recommended strawberry clover, salt water couch, puccinellia, barley grass, tall wheat grass, saltbushes and others for soils with different salinities (Table 1, Malcolm 1986).

Table 1. A guide to selecting salt tolerant forage plants for saltland types in the agricultural areas of Western Australia *

Saltland type and condition			Site severity		
			Mild	Moderate	Severe
Hillside seepage	Soil surface wet in summer		Strawberry clover, Paspalum, Couch, Kikuyu	Salt water couch	Salt water couch
	Soil surface dry in summer		Puccinellia, Barley, Tall wheat grass	Puccinellia	Puccinellia
Saline valley floors	Rainfall >375 mm		Puccinellia, Barley, Tall wheat grass	Puccinellia, Saltbushes**	Samphire
	Rainfall <375 mm	Commonly flooded	Saltbushes, Puccinellia, Barley	Saltbushes, Puccinellia, samphire	Samphire
		Seldom flooded	Barley, Bluebushe, Puccinellia, Saltbushes	Saltbushes, Bluebush, Puccinellia	Saltbushes, Samphire, Puccinellia
Dryland salinity	Rainfall <375 mm	Never flooded	Barley, Bluebush, Saltbushes	Bluebush, Saltbushes	Bluebush, Saltbushes

* The recommended plant is underlined. Others listed are also capable of reasonable growth,
** Saltbushes are only recommended in areas with less than 500 mm annual rainfall.
*** Source: Malcolm (1986)

Distribution of red (Cervus elaphus) and fallow (Dama) deer in Australia
Seventeen species or subspecies of deer were introduced into Australia during the last century by Acclimatisation Societies. Of these, only fallow, red, rusa, sambar, chital and hog remain today (SCA 1980). While there are no accurate estimates of feral and farmed deer in Australia, the figures published in 1980 by the working party appointed by the Animal Production Committee of the Standing Committee on Agriculture are a reasonable guide.

3.1 Feral deer
There is a lack of accurate information on the total population of the feral herd. However, there are about 20000 fallow and 11000 red deer distributed in Australia. The largest populations of fallow deer are in Tasmania, with the rest being in South Australia, Victoria, New South Wales and Queensland. Two major feral populations in New South Wales are located at Rangers Valley in the Glen Innes district and Lake George on the South Tablelands. In South Australia, feral fallow deer are distributed in the Adelaide Hills and in the South-East. In Queensland, fallow deer are confined to the west of Stanthorpe between Pikedale and the Severn River, and the area between Warwick and the Dividing Range (SCA 1980). Fallow deer are the most widespread and numerous in Australia.

Red deer have adapted to most environments and have adjusted from the sub-tropics to the temperate zone, from sea level to 1800 m, from near-desert conditions to more than 760 cm of rainfall, and from forests to open plains. Red deer are most numerous in the Brisbane River Valley of Queensland, the Mudgee-South Coast area of New South Wales, the Grampians of Victoria and in the Pinjarra region of Western Australia and the ACT (Anderson 1984).

3.2 Farmed deer
While there are more than 40 recognised species and numerous subspecies of deer through the world, many are not suitable for modern agricultural husbandry and must be kept in an open environment. Farmed deer in Australia are limited to the six existing species, and estimated at 2000 head on 300 farms in 1985 (Mackay 1985) and 160000 head in 1998 (Mackay 1998). Of these 40% are red, 50% are fallow with 10% of other species. However, fallow deer are dominant species in New South Wales, Tasmania, Western Australia and South Australia, but Queensland has more red deer (English 1984). The number of red deer has increased dramatically in South Australia during the last few years.

Salt intake of grazing deer
Animals can ingest salt from water, pastures, soils (Wilson 1978) and other mineral supplements, making it difficult to quantify the salt intake under grazing conditions. Salt intake of grazing animals is often influenced by environmental conditions (temperature, rainfall), pasture management (grazing intensity, fertiliser application), and animal factors (maturity stage, selective grazing, species or breed etc.).

Pastures
Under a Mediterranean environment in southern Australia, pastures are dominated by annual species such as medics, subterranean clover, ryegrass and barley grass etc. During the vegetative stage, pastures generally have a low sodium content (Xu *et al.* 1994), which increases with plant maturation. Ru (1996) reported that sodium content (on dry matter basis) in subterranean clover increased from 0.3-0.5% in August to 0.8-1.6% in November, with a large variation among cultivars. Clover seeds have a low sodium content (0.06-0.11% dry matter).

In the cropping areas affected by salt, puccinillia (*Puccinellia ciliata*), tall wheat grass (*Thinopyrum ponticum*) and Chenopodiaceous plants (e.g. *Atriplex, Kochia and Bassia spp*) have been planted for the improvement of soil conditions due to their low transpiration rate, high efficiency of water use, drought and salinity resistance (Sharma 1978; Wilson 1978; Leigh 1986; Barrett-Lennard 1999).

Puccinellia which originated from the west coast of Turkey, is a winter active perennial grass suited for saline and waterlogged land. It grows in areas with 300 mm or more annual rainfall and performs better on alkaline soils than on acid soils. This pasture is the key to production of grazing animals on salt affected land in Eyre Peninsula and in the Upper South East in South Australia. The dry matter digestibility of Puccinellia is over 70% during September and November, and protein content declines from 22% in September to 15% in November. While few grazing data are available, the palatability of this pasture varies between varieties. For example, Rottnest Island prostrate ecotypes is highly unpalatable, whereas the prostrate ecotype from Geraldton is highly palatable (Barrett-Lennard 1999). Tall wheat grass, originated from Balkans, Asia Minor and southern Russia, is adapted to highly alkaline soils and salt seepage areas. It is less tolerant to salinity than Puccinellia. It grows in warmer months, with a moderate palatability and requires a heavy rotational grazing system. It is only moderately palatable (Nichols 1998). While it has been reported that on saline soils there are increases in salt uptake and in salt concentrations in the plant materials, and the increased salt concentrations in the shoots of waterlogged plants have adverse effects on plant growth and survival in the longer term (Barrett-Lennard and Nulsen 1989), there is limited information on the salt intake of animals grazing these pasture species.

Chenopodiaceous plants supply a large amount of forage during drought periods and have remarkable capacity to remain leafy and viable under high radiation and temperature levels (Sharma 1978). The common feature of *Atriplex* leaves is their vesiculated hairs, which are extremely rich in salt and perform functions such as absorption of water from the atmosphere, water storage, insulation against transpiration and salt secretion (Wood 1925; Mozafar and Goodin 1970). These shrubs are grazed by sheep and cattle, and the intake of A. *nummularia* (oldman saltbush) was sufficient to maintain sheep and to allow a small gain in weight. The bodyweight production per unit area was similar for sheep and cattle, but sheep selected more green grass than cattle which ate more dry grass and saltbush (Wilson 1966a). While proximate analyses of the leaves of these shrubs show that they are high in crude protein and ash during summer, the high ash content up to 30% of the dry matter is a disadvantage, as high salt intakes may be detrimental to grazing animals (Wilson 1966a; Wilson 1978).

There is a variation in nutritional quality among species of saltbushes. Leaves of saltbushes have a crude protein content of 16.7-25.2%, crude fat of 1.0-1.6%, crude fibre of 7.8-10.4% and ash of 18.5-27.2% on a dry matter basis. Sodium content ranges 0.2-5.6% on a dry matter basis. Digestible dry matter ranges from 74.5% to 78.8% and digestible energy from 3.2 Mcal/kg to 3.4 Mcal/kg (Khlil *et al.* 1986). Rehman (1992) also found that among 8 saltbush species, the dry matter digestibility ranged from 33% to 62%, and nitrogen digestibility varied from 51% to 81%. Crude protein content in dry matter varies from 10% to 20% and ash content from 13% to 23%. There was no correlation between preference of sheep and the content of crude protein, ash content or sodium content of saltbush samples. The sodium content in saltbush is much higher than the 0.06% level recommended for beef cattle (NRC 1976); the level of 0.5% recommended for goats (NRC 1981) and 0.04-0.1% recommended for sheep (NRC 1975). The digestible energy content is higher than those required to meet the needs of dry (2.2 Mcal/kg) and lactating (2.5 Mcal/kg) cows (NRC 1976) and can meet the requirement of sheep and goats (NRC 1975; 1981). However, the nutritional value of these bushes for deer and the impact of sodium content on deer production are not clear.

3.3 Water

Surface water supplies are not regarded as a major source of minerals for the grazing animal. However, evaporation, which is more significant in summer, from streams and lakes results in a concentration of the dissolved solids. Land management strategies also affects the salinity of surface water available for grazing animals. For instance, the replacement of deep-rooted trees by shallow rooting grasses in the clearing of native forest for agriculture in south-west Western Australia increased stream salinity. During the irrigation season, drought periods following prolonged floods, the concentration of salts may increase significantly (Anon 1976). In the field situation, evaporation from troughs in summer can cause an increase of 10% in concentration of salts even though the troughs are cleaned regularly (Wilson 1978).

Groundwater is more saline than surface water from being in contact with soil and rock for longer periods and has been concentrated by plants through transpiration. Judson and Mcfarlane (1998) indicated that the quality of underground water is variable and significant quantities of Na, Ca and Mg salt may be consumed by grazing animals. Bore water in the Northern regions of Australia usually contain less than 5000mg/litre of total dissolved salts whereas in the southern parts of the country concentrations are in excess of 10000 mg/litre of total dissolved salts. This concentration is near the maximum tolerable concentration for mature non-lactating livestock (Judson and Mcfarlane 1998).

Holmes and Waterhouse (1983) reported typical concentrations of Na, Ca and Mg in groundwater from selected sites in the south-east of South Australia. The data indicate that water with the higher cation concentration could provide about 20-100% of Na and about 5-20% of the daily Ca and Mg needs of the mature animals. Total salinity is higher in summer than in winter (Table 2). However, in many places, especially in north-eastern and central Australia, the salinity of ground water is unknown (Anon 1976).

Soils

Livestock cannot avoid ingesting soil during grazing. Factors influencing an increase in ingestion of soil are high stocking rates, areas of poor drainage, poor pasture growth, feeding root crops or grain supplements in mud or dust, and when stock are grazing stubbles and subterranean clover pasture where grain and clover burr are buried. On short pastures, cattle can ingest over 100g soil/kg herbage DM (Dewes 1996) and sheep up to 300g soil/kg herbage DM (Thornton 1983). Under normal grazing conditions, ingested soil can be a source of more minerals than ingested pasture (Healy 1973). No studies have been undertaken to determine the intake of soil by deer while grazing.

Table 2. Representative analyses of water in the south-east of South Australia (Holmes and Waterhouse 1983)

Source	Main cations (mg/litre)			Total salinity (mg/litre)
	Na	Ca	Mg	
Unconfined aquifer, Mt Gambier	81	113	18	690
Coastal Spring, Ewens Ponds	46	73	20	387
Confined aquifer, Mt Gambier water supply	115	71	30	612
Unconfined aquifer, Padthaway	453	109	63	1678
Groundwater drain				
July	192	65	38	855
December	333	45	58	1224

Impact of salt intake on animal production

The salt intake has to match the requirement of deer for optimum production. It has been shown that sodium deficiency influences pasture selection and appetite, and increases appetite for salt or salty foods (Blaxter *et al.* 1974). Research conducted at the Rowett Research Institute also indicated that when supplementing sodium with salt blocks on pastures with low sodium content, stags licked salt blocks and hinds sometimes drank the urine of their sucking calves to increase their sodium intakes. The ratio of sodium and potassium is a valid index of sodium status in deer as in sheep (Blaxter *et al.* 1974). While there is little data available demonstrating the effect of sodium deficiency on deer production, research with other livestock species shows that growth rate, feed utilisation efficiency and milk yield can be depressed if sodium is limiting (Xu *et al.* 1994).

Although there are no reports on the impact of excessive sodium intake on the performance of grazing deer, the effect of high sodium intake on water intake, feed intake and consequently animal production of other livestock species such as sheep has been studied comprehensively.

Water intake

The water intake from forages of grazing animals is dependent on ambient temperature, forage moisture and forage mineral content. Inglis (1985) reported the normal water intake of animals (Table 3), but the type of diet has a significant influence on water requirement (Inglis 1985; Wilson and Hindley 1968). For example, water intake of red deer varies from 0.27 litre/kg DM intake for a grass diet to 3.82 litre/kg DM on concentrated pellets (Bonengel, 1969). Fallow deer require less water per unit of feed intake (Denholm 1984).

Ingestion of excess sodium by stock may lead to a higher water requirement and a decreased tolerance to saline drinking water, especially in the salt affected cropping areas. In these regions saltbush and bluebush may comprise part of the available feed and stock are dependent wholly or partially on salty water. It was evident that when grazing saltbush, water intake of sheep increases. The maximum water intakes varied from 4 litre/day in the summer of a good season to 12 litre/day during a drought (Wilson 1978).

Table 3. Normal water intakes of animals (Inglis 1985)

Animal			Daily consumption (litres/day)
Merino ewe			Up to 3.7 in summer; 1.6 average over a year
Beef cow			Up to 53 in summer; 35 average over a year
Dairy cattle			70
Horses			45
Pigs			
	Sow and litter		23-27
	Sow (pregnant)		11-14
	Grower	23 kg	3-5
		45 kg	7
		68 kg	9
		90 kg	11
Poultry (100 birds)			
	Laying hens		33
	Broilers		30 (higher now)

Rumen digestion

Over 90% of the ingested sodium is excreted in the urine (Wilson 1966b), and the kidney maintains fluid and electrolyte balance in animals drinking salty water, if sufficient fresh water is available. However, the digestive system is unable to cope with a large volume of saline water ingested to maintain fluid balance (Wilson and Dudzinski 1973), and can lead to a higher osmotic pressure and a lower microbial population and activity in the rumen as found in sheep (Potter *et al.* 1972). The degree of change in osmotic pressure, microbial population and activity depends on the type of ration.

For example, sheep have a higher tolerance to saline water when fed on lucerne chaff than on oaten chaff (Wilson and Dudzinski 1973). There is no quantitative information on the effects of high sodium intake on the digestion in the rumen, but Elam (1961) recorded an increase in the rate of passage of feed through the gut when salt was added to the diet.

Feed intake and animal production

While there is no data on the feed intake and growth rate of deer at different levels of salt intake, studies with other animal species shows that increasing salt intake often leads to a higher water requirement and a reduction of feed intake, especially in hot weather, on saline vegetation or on a poor quality ration. Wilson (1966b) reported that the addition of 0.9 or 1.2% sodium chloride to the drinking water for sheep fed saltbush diets caused a marked decrease in intake and a substantial loss of body weight, with a small decrease in digestibility. Generally, total salt content of 1% in drinking water will not influence sheep performance. Saline water about 1.5% of total salts may not affect animal production if the environmental conditions are good. However, over 2% total salts in the drinking water is detrimental to production and survival of sheep (Wilson 1978).

The response of animals to salt intake is dependent on the age of animals. For adult sheep, 1.6% of total salt in water significantly depresses weight gain in summer, but for lambs, 1.3% of total salt causes a reduction in body weight gain and wool growth, and increases the incidence of diarrhoae. Even water containing 1.0% of total salts causes some reduction in weight gain and wool growth of lambs (Wilson 1975). Potter and McIntosh (1974) also reported that drinking water containing 1.3% sodium chloride increases lamb mortality at birth, particularly for twins.

Sheep on saline water have higher body water content and their carcases contain less fat, but more water and protein than sheep on fresh water (Walker *et al*. 1971). This might indicate that weight change, without determination of body composition, is probably not adequate for assessing the effect of saline water on animal production.

Salt tolerance of deer

Salt tolerance has been interpreted as the absence of a depression in the intake of a certain ration, and is well defined for most livestock species except for deer. Under grazing condition, animals may ingest excessive salt through feed, drinking water, and ingestion of soil (Howell 1996). Excessive intake of sodium is one of the more commonly encountered problems and often causes loss of appetite, reduced milk production and reduced growth (Xu *et al*.. 1994).

Water is one of major sources of salt for grazing animals. 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 1966b). However, 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, although saline water (1.3% NaCl) had no effect on the concentrations of sodium, potassium, calcium or chloride in the blood plasma (Peirce 1959; 1963). Australian Water Resources Council recommended that the ground water might be suitable for some stock if the content of total dissolved solid is 3000-7000 mg/litre. If the content of total dissolved solid is over 14000 mg/litre, this water cannot be used by any stock (Anon 1976). Inglis (1985) summarised the salinity tolerance of livestock and poultry based on previous research (see Table 4). The salinity tolerance can vary with environmental conditions, type of feed, or physiological stages (see Table 5, Anon 1969). Sheep and cattle grazing greenfeed can tolerate higher concentrations of salt in water than the same stock on dry feed. Stock grazing on saltbush are less tolerant than those grazing other types of pastures. Pregnant, lactating or young animals have a poorer tolerance to saline water than dry mature animals (Inglis 1985). Peirce (1957; 1962; 1966; 1968a; 1968b) and Wilson (1975) 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. Therefore, the safe values for salinity of 1.2% on grassland and 0.8% on saltbush were recommended by Wilson (1975), but these values should be further reduced for ewes and lambs, if lambs are born in summer.

There are large differences in salinity tolerance between animal species or breeds within species (NRC 1980; Inglis 1985; Judson and McFarlane 1998). NRC (1980) reported that the maximum tolerable concentration were 35 and 16-35 g/kg DM for sheep and cattle, respectively. For sheep different tolerances are observed when fed on different rations or levels of intake due to individual differences in their ability to excrete or tolerate sodium chloride (Wilson 1966b).

Table 4. Salinity tolerance of livestock and poultry (mg total soluble salts/litre water)

Animal	Maximum concentration for health growth	Maximum concentration to maintain conditions	Maximum concentration tolerated
Sheep	6000	13000	Depends on type of feed
Beef cattle	4000	5000	10000
Dairy cattle	3000	4000	6000
Horses	4000	6000	7000
Pigs	2000	3000	4000
Poultry	2000	3000	3500

Source: Inglis (1985)

Table 5. Upper limits used by State Authorities for total salts in water (ppm) for livestock (Anon 1969)

Class of livestock	New South Wales	Victoria	Queensland	South Australia	Western Australia	Northern Territory
Poultry	4000	3500	3500	3000a	3000	
Pigs	4000	4500	5500	3000a	4500	
Horses	7000	6000	5500b	7000	6500	6000
Cattle						
Dairy	10000	6000	5500b	7000	7000	6000
Beef	10000	7000	8500c	10000	10000	10000
Sheep						
Lamb, Weaners		4500			10000	
Ewes in milk		6000			10000	
Adult, on dry feed	14000	7000e	14500	13000	13000	12000
Adult, on green grass		15000	18500	18000	18500d	15000

Notes

a: 4000 ppm if on salt-free rations, 1500 ppm if on high salt diet.

b: 7000 ppm if on green feed.

c: 10000 ppm if on green feed.

d: for short period.

e: If unaccustomed to saline water; if accustomed, up to 15000 ppm.

4. Potential deer farming in the arid and semi-arid areas

In the arid and semi arid regions which cover 70 to 75% of the continent (Ffolliott, *et al*. 1995), with only 2-3% of the population (Mitchell 1979), rainfall is variable and of low intensity. Typically the land is flat and only wide, shallow storage of water is possible. The high evaporation rates result from high radiation, high temperature and low humidity, especially in summer. Water quality, especially high concentrations of salts present some of the greatest limitations for the use of water by livestock (Anon 1976; Goodspeed and Winkworth 1978).

The development of deer farming in the arid and semi-arid areas of Australia offers diversification opportunities for existing farmers as well as new farmers. It has been well understood that deer are very adaptable and can be farmed in most parts of Australia (Mackay 1998). The competition between cattle and deer for feed resources is minimal due to little dietary overlap between the two species (Ffolliott *et al.* 1995). More importantly, deer are more efficient converters of fodder to meat than cattle or sheep, have a dressing percentage of around 60% which is significantly better than either sheep or cattle (Anderson 1984). Blaxter (1974) also reported that the first class meat obtained from a lean young deer carcass is 33% of its empty body weight. In sheep of a similar size the amount of first class meat obtained is only 18% of empty body weight. The feed conversion ratio was 2.8-3.8 which was half that usually found for cattle and better than that obtained in intensive lamb production. Drew and Greer (1977) estimated that pasture dry matter intakes for every kg carcass gain were 9.5 kg for red deer and 30 kg for lamb. Wilson (1984) also confirmed the potential advantage of deer meat production over traditional beef production and found that deer carcasses have little fat and most is subcutaneous, intermuscular and retroperitoneal.

The vegetation of large areas of arid and semi-arid Australia is dominated by species of the genera *Atriplex* (saltbushes) and *Kochia* (bluebushes). These shrubs are invaluable feed resources in summer of grazing sheep and cattle. While the nutritional value of these bushes are evaluated by a number of researchers, the high salt concentration in leaves is a disadvantage to animal production. High salt intake of grazing animals from bushes and salty water in these regions, especially over drought periods, causes a higher water requirement, which may limit the expansion of beef industry in these regions (Wilson 1979). Thus the lower daily water requirement of deer in comparison with beef cattle offers a great opportunity to use this land for deer farming. However, farmers need information on salt tolerance of deer to optimise the production system and eliminate animal ethics concerns.

Conclusion

Animals require sodium for growth, reproduction and other physiological functions. However, in southern Australia or in the salt-affected areas, excessive intake of sodium often occurs through drinking water, ingestion of salty feed and soil, especially in dry summers when temperature and evaporation rates are high. The impact of excessive sodium intake on feed intake, growth rate and water requirement has been well documented for most livestock species except for deer. While the salt tolerance levels of grazing animals have been defined, especially for sheep, there is no data available for grazing deer. More importantly, the tolerance level is influenced by species, breeds within species, physiological stages of animal, feed type, feeding level, and environmental condition. Therefore the data obtained from sheep and cattle cannot simply be applied to deer. To optimise deer production in southern Australia and to successfully develop the deer industry in the dry areas or salt-affected areas the following research is required;

i) basic information of sodium status of deer in these regions particularly from an animal ethics point of view,

ii) an understanding of the impact of excessive sodium intake on deer production,

iii) tolerance levels of different deer species at various physiological stages.

5. Recommendations

- Determine nutritional value of chenopodiaceous plants for deer; effects on water consumption (water turnover) and excretion of sodium and potassium in deer;

- Monitor sodium status of grazing deer, especially in dry summer;

- Determine the effect of ingested soil on salt balance in deer;

- Determine the effect of salt intake on digestion in the rumen, feed intake and performance of deer.

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