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Practical considerations for diagnosis and management of Cu status of deer

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ABSTRACT

Accurate diagnosis and appropriate management are essential for effective maintenance of an adequate copper (Cu) status of farmed deer. Deer with liver and serum concentrations below 60 μmol/kg fresh tissue and 5 μmol/L, respectively, are at risk of clinical disease or reduced growth rate. Deer with adequate serum Cu may have low liver Cu concentrations, but those with low serum Cu usually have low liver Cu concentrations. No sex differences in tissue Cu concentrations have been reported. Tissue Cu concentrations fluctuate seasonally, being lowest in late winter-early spring, and commonly with greater reduction from autumn to spring in adults than in younger deer. There is insufficient known about the Cu metabolism of deer to enable a prediction of future Cu status to be made. Analysis of forage is warranted as an aid to establish the underlying cause of deficiency and to assist management decisions.

Oral Cu oxide wire particles and injectable Cu/EDTA are licensed animal remedies for Cu supplementation in deer. Treatment frequency depends on tissue concentrations, dietary factors, production goals and nutritional management. Recent research shows high rates of Cu sulphate application to pastures and grazing chicory can also elevate deer tissue Cu concentrations. Monitoring the efficacy of supplementation using changes in liver Cu concentrations is essential.

Keywords: deer, blood, liver, Cu, season, age, sex, Cu supplementation

INTRODUCTION

There is a high level of awareness amongst veterinarians and producers that farmed red and wapiti deer are susceptible to Cu deficiency syndromes, and Cu supplementation is common. The dynamics of Cu metabolism and the diagnosis and prevention of Cu deficiency in deer are complex (Wilson, 1998). Frequently decisions about supplementation are subjective and desired outcomes of maintaining adequacy and cost effectiveness are not achieved (Wilson & Audigè, 1998; Beatson *et al.,* 2000). This paper briefly reviews current knowledge and the key factors in diagnosing and managing the Cu status of deer to maintain optimum health and productivity.

AN ASSESSMENT OF COPPER STATUS AND DEFICIENCY IN DEER

Clinical signs

Oesteochondrosis, diagnosed by gross pathology, and enzootic ataxia, diagnosed by histopathology, are clinical disease entities associated with Cu deficiency (Wilson & Grace, 2001). Retardation of growth may occur as a result of low tissue Cu concentrations. No relationship has been established between tissue Cu concentrations and velvet antler growth. The relationship between clinical disease, growth and production, and tissue Cu concentrations in deer, has recently been reviewed (Wilson & Grace, 2001). That information was used to propose deficient, marginal and adequate tissue reference values for the diagnosis of Cu status. Data suggested that deer with liver Cu concentrations below 60 μmol/kg fresh tissue and serum Cu concentrations below 5 μmol/L are at risk of clinical disease or reduced growth rate. Liver Cu concentrations between 60 and 100 μmol/kg fresh tissue and serum concentrations 5-8 μmol/L are considered marginal while liver and serum Cu concentrations of >100 μmol/kg fresh tissue and >8 μmol/L, respectively, reflect an adequate Cu status.

Age

Foetal (Reid *et al*., 1980), and neonatal (Grace & Wilson, unpublished) liver Cu concentrations are significantly higher than those in older deer. Survey data from farmed deer (Wilson & Audigè, 1998) showed serum Cu concentrations in 3 to 15 month old deer were significantly higher than those of yearling and adult deer, respectively. A similar pattern has been observed during current studies on a deer research farm (Grace & Wilson, unpublished). However, data of Beatson *et al*. (2000) showed only a marginally higher serum Cu in rising 1-year-old deer compared with rising 2-year-old and older deer, although supplementation may have masked differences.

After the neonatal period, differences between age groups are likely to be due, at least in part, to management systems which normally restrict feed intake for adult deer but not for younger deer. However, there may also be differences between ages in absorption, metabolism and storage of Cu.

Sex

To date there has been no report of sex differences in tissue Cu concentrations between deer of equivalent ages. (Wilson & Audigè, 1998). More recent data in rising one-year-old deer (Grace & Wilson and Wilson *et al*., unpublished) supports that observation.

Species

There have been few comparative studies of deer species differences in susceptibility to Cu deficiency. Mackintosh *et al*. (1986a) showed lower liver Cu concentrations and a higher incidence of enzootic ataxia in Wapiti and wapiti x red hybrid deer, than in red deer that were managed together. Waldrup & Mackintosh (1992) suggested that increased susceptibility of wapiti to parasitism may reduce Cu absorption, particularly after supplementation with oral oxidised Cu wire particles.

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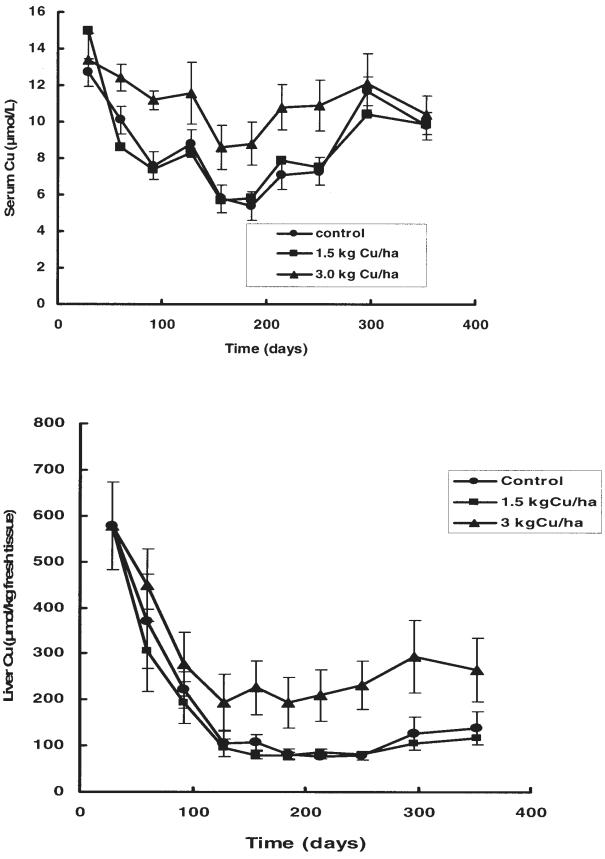
Season

A survey of serum Cu concentrations from commercial deer farms (Wilson & Audigè, 1998) showed lowest serum concentrations in late winter/early spring. This trend was particularly evident in yearling and adult animals in which serum Cu concentrations fell by means of 3 and 5.2 μmol/L, respectively, from autumn to spring. Walker *et al.* (2000) reported a reduction in mean serum Cu of 2.7 μmol/L from February to September. A similar seasonal trend was observed in both serum and liver Cu concentrations in samples collected from deer slaughter premises (Mackintosh *et al.*, 1986, Wilson & Audigè, 1998b), and more recent data is presented in Figure 1.

Animal origin

There are substantial differences in deer tissue Cu concentrations between farms (Audigè 1995; Beatson *et al.*, 2000). These differences may be attributable to the large range of factors influencing tissue Cu concentrations, including soil and pasture characteristics, grazing and nutrition management, concurrent disease and supplementation practices. Tremaine-Boon *et al.* (2002) observed significantly higher liver Cu concentration in deer of feral compared with farmed origin, suggesting diet is a significant contributing factor. Reid *et al.* (1980) and Harrison *et al.* (1989a) reported a similar pattern. The latter authors reported different mean liver Cu concentrations related to soil type, although no statistical analysis or ranges were presented. It is likely that differences between farms on the same soil type would vary as a result of management practices, so caution should be exercised in extrapolating soil Cu concentrations to animal tissue concentrations.

FIGURE 1. Mean (±SE) serum (top) and liver (below) concentrations of red deer (n=11/group) aged 4-16 months grazing pasture topdressed with two rates of copper in mid March (day 0).



Serum:liver copper relationships

Data from paired serum and liver Cu analyses (Mackintosh *et al.*, 1986b), show that deer with adequate serum Cu may have lower liver Cu concentrations, but those with low serum Cu usually have low liver Cu concentrations. Those authors propose a statistical probability model for interpretation of serum Cu concentrations. Thus serum Cu concentration may be used to confirm adequacy or inadequacy at the time of sample collection, but cannot be used to predict liver Cu stores. A similar pattern was reported by Clark & Hepburn (1986) and Walker *et al.* (2000).

Forage copper and interactions with other mineral elements

The relationship between forage Cu concentration and other mineral elements potentially influencing Cu absorption and liver storage is not well understood in deer (Frudenberger *et al.*, 1987). A study by Osman & Sykes (1989) concluded that Cu metabolism in sheep is more sensitive to changing dietary molybdenum (Mo) than in deer, but that deer are more sensitive to changing dietary sulphur (S) than sheep. The impact of the Cu x Mo x S interaction in deer on their Cu metabolism has not been fully determined and there is insufficient knowledge to predict accurately the deer Cu status from forage Mo and S. While it has been demonstrated that increasing iron (Fe) and zinc (Zn) intakes impairs Cu absorption in sheep and cattle, there are no data for deer. Nevertheless, Fe and Zn should be considered when assessing the Cu status in deer.

Forage Species

Preliminary observations (Barry *et al.*, 2001) showed significantly higher blood and liver Cu concentrations (e.g. 461 v 175 μmol/L/kg fresh tissue) in May in deer grazing chicory (mean Cu concentration 10.8 mgCu/kg DM), when compared with rye grass/white clover pastures (mean Cu concentration 7.8 mg/kg DM) during the autumn on a copper-marginal research farm where pasture Mo concentrations are low (0.25 mg Mo/DM). Further research (Wilson *et al.*, unpublished) has shown a five-fold increase in liver Cu in 12-month-old deer grazing chicory during autumn and spring, when compared with those grazing rye grass/white clover alone. At the end of the winter grazing period, during which all deer had grazed ryegrass/white clover, 6 of 23 grazing chicory in autumn had liver Cu concentrations of less than 100 μmol/kg fresh tissue, while 17 of 22 deer grazing pasture in autumn were in that range. One deer grazing each forage species in autumn were in the deficient range (<60 μmol/kg) at the end of the winter grazing period.

COPPER SUPPLEMENTATION

If deer tissue Cu concentrations are in the deficient or marginal ranges, pasture mineral analysis should be

TABLE 1: Summary of data from the literature on the efficacy of Cu supplementation in deer expressed as the increases in mean liver Cu concentration (μmol/kg fresh tissue) above untreated controls.

Study	Treatment^	Age	Month of Treatment	No. of deer	Months after treatment						
					0.5	*1*	*2*	*3*	*4*	*5*	*6*
Booth *et al*, 1989	10 g CuO	4 m	Mar	11		491	594	427	136	114	25
Harrison *et al,* 1992 *	5 g CuO	4 m	Mar	8			300	140		20	
	15 g CuO	4 m	Mar	8			600	280		80	
	10 g CuO	9 m	Sept	9		380		120			50
	20 g CuO	9 m	Sept	9		580		220			150
	10 g CuO	14 m	Feb	8		350	300		230		
	10 g CuO	≥ 3 yr	Feb	9		410	490	240			
	20 g CuO	≥ 3 yr	Feb	9		510	510	380			
	50 g CuO	≥ 3 yr	Feb	9		700	800	380			
	10 g CuO	≥ 3 yr	Sept	9		570		180			80
	20 g CuO	≥ 3 yr	Sept	9		700		400			180
	50 g CuO	≥ 3 yr	Sept	9		1300		400			180
Harrison *et al*. 1989b	Cu-EDTA mean 0.28 mg/kg	3-5	NS	6	172	207**					
	Cu-EDTA mean 0.58 mg/kg	3-5	NS	6	452	316**					
	Cu-EDTA mean 1.23 mg/kg	3-5	NS	6	881	640**					

*Data extrapolated from graph, therefore approximation only. Data converted from mg/kg DMB using DM estimate at 25%.
^CuO = Cu oxide wire particles orally and Cu-EDTA as an injectionNS = Not stated; ** = 5 weeks after treatment.

undertaken to evaluate dietary Cu concentrations and intake as well as to determine the potential interactions that other elements, such as Mo, that may be interfering with Cu absorption and storage. In some situations, soil element analysis and pH determination may further help determine the underlying cause(s) of low animal tissue Cu concentrations. This data may provide some direction for the most appropriate Cu supplementation method.

Copper oxide wire particles given orally and injectable CuEDTA are licenced Animal Remedies for use in deer. Available data for liver Cu concentrations after supplementation are presented in Table 1.

Copper oxide wire particles provide slow release Cu (Wilson *et al*. 1989), and a dose related increase in liver Cu has been demonstrated (Harrison *et al*., 1992). Injectable Cu-EDTA provides a rapid increase in liver Cu concentration, but of a shorter duration than shown with oral Cu oxide wire particles (Harrison *et al*., 1989b). These observations demonstrate the difficulty in assessing the likely response to treatment and the treatment frequency required, because of the range of confounding factors involved, thus reinforcing the need to carefully monitor response to supplementation on every individual farm. Liver is the most appropriate tissue to analyse for Cu to demonstrate responses to supplementation.

Preliminary data on the influence of pasture topdressing with copper sulphate in the autumn on tissue Cu concentrations in young growing deer (Grace *et al*., 2001) are presented in Figure 1. These data show, in deer, a good response in serum and liver Cu concentrations at an application rate of 12 kg Cu sulphate (3 kg Cu/ha) when compared with the industry recommended application rate of 6 kg Cu sulphate (1.5 kg Cu/ha) for pastures. These results suggest that the currently used application rate for Cu amended fertiliser may be insufficient to elevate deer tissue Cu concentration as their Cu requirements appear to be similar to cattle, but greater than those for sheep. Investigations are ongoing.

MONITORING SUPPLEMENTATION

Survey data (Audigè, 1995; Wilson & Audigè, 1998) shows that not all supplementation achieves the desired effect in the animal. Monitoring showed that herds fell into the following categories: Cu was not used where supplementation was not needed; Cu was not used where Cu supplementation was needed; Cu supplementation was not used when needed; Cu supplementation was used but the response did remove all animals from the "at risk", or deficient category; and Cu was used and achieved adequate tissue Cu concentrations. Within farms, Cu usage was variable between age-groups, and between seasons within and between age groups, suggesting that farmers are not always confident about their supplementation practices. Beatson *et al*. (2000) made similar observations. These observations suggest that there is significant opportunity for better decision-making on deer farms about Cu supplementation. Firstly, establishment of the animal tissue Cu status must be undertaken, incorporating the factors discussed above, before the need for supplementation is determined. This avoids the risks of wastage of time and money, and inappropriate Cu use, causing toxicity. If supplementation is prescribed, strategic periodic measurement of liver Cu concentrations is essential to ensure supplementation is achieving the desired outcome of animal tissue Cu sufficiency on a continuing basis.

CONCLUSION

Diagnosis and prevention of Cu deficiency in farmed deer is complex and multi-factorial. The first necessary step of recording tissue Cu concentrations must be followed by careful analysis and interpretation in view of the age group, season, forage, management and supplementation programme on a given property. Where supplementation is necessary it is essential that tissue Cu be monitored subsequently to ensure effectiveness of treatment.

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