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Editorial

Mineral nutrition of sheep: new insights into interactions when grazing vegetative crops

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The paper by Dove and Kelman (2015*b*) in this issue of *Animal Production Science* continues a series of Australian publications addressing the need for mineral supplements for sheep grazing dual-purpose wheat (Dove 2007; Dove *et al.* 2007, 2012; Dove and McMullen 2009). Responses have been variable but overall assessment indicates there are positive growth responses to sodium (Na) and magnesium (Mg) supplements. The specific causes of the responses have not been easy to interpret due to a multiple mineral imbalance. The wheat plants are very low in Na (often 10–20% of requirement) and marginal in Mg and calcium (Ca); the situation is further complicated by high potassium (K) (800–1000% of requirement) (Dove and Kelman 2015*b*). The high K and low Na potentially reduce Mg absorption and the high K may also interfere with Ca metabolism by causing a high, positive dietary cation–anion difference (Masters and Thompson 2015).

It is worthwhile examining these responses in more detail. In early experiments, significant liveweight responses (30–50%) were measured following supplementation with a mixed mineral supplement (containing Mg, Na and Ca) or to supplements that contained Na, Na + Ca or Na + Ca + Mg (Dove and McMullen 2009). The authors concluded that the responses were most likely due to Na and Mg supplementation. They went further in suggesting that the response may be primarily due to increased Mg supply to the sheep, either as a result of specific Mg supplementation or as a consequence of Na supplements lowering the K : Na ratio and increasing Mg availability. These conclusions are similar to those of previous studies where liveweight responses in young sheep were measured in both Na- and Mg-supplemented sheep (Dove *et al.* 2007). In a subsequent study, young sheep grazing dual purpose wheat did not respond to supplements of Na and Mg (Dove *et al.* 2012). Importantly, there do not appear to be any cases where responses to Mg + Na supplementation have markedly exceeded those to Na supplementation alone. This means the responses are not additive and therefore unlikely to be mutually exclusive (Dove and Kelman 2015*b*). It has been assumed that Na is influencing Mg absorption and this is the primary cause of the response, although a direct response to Na has also been considered. Similar conclusions have been made from limited experiments with cattle (Bell and Dove 2012). Notably, there have been significant responses to Na alone but no similar responses for supplements of Mg alone: responses have been to Mg used as fertiliser or mixed with roughage (Dove and McMullen 2009; Dove and Kelman 2015*b*).

There are some interesting inconsistencies with the literature when these responses are explored further. As identified by Dove and Kelman (2015*b*), a broad review of the literature to date, does not indicate that Mg deficiency causes a reduction in growth or that Mg supplements are associated with growth responses (Suttle 2010). Grass tetany is always described as the first sign of Mg deficiency. In one of the earliest studies on Mg deficiency, the authors observed ‘fair growth when suddenly terminated by fatal convulsions’ or, when later referring to growth indicate no ‘appreciable loss before being overtaken by death’ (Kruse *et al.* 1932). Since this time, little has been published to alter this perception. By contrast, in the Australian studies with grazing wheats, grass tetany has not been reported but growth responses have. This would indicate the responses are either not related to Mg deficiency or are related to an interaction between Mg and other nutrients.

Another explanation is Na deficiency. There are few reports in the literature of rapid changes in feed intake and growth resulting from a lack of Na alone, with a general acceptance that it takes several weeks of Na depletion before appetite declines and weight gain decreases (Suttle 2010). Growth responses in sheep grazing young wheat crops have been reported in 3–4 weeks (Dove and McMullen 2009). During Na depletion abnormal appetite exhibited as a craving for salt and geophagia is also expected. In comparison, no abnormal appetite has been reported in sheep grazing dual-purpose wheat. Others, feeding lactating ewes, failed to observe any change in feed intake or growth when ewes were fed a diet containing 0.02% Na for 8 weeks (Morris and Peterson 1975). It is worth pointing out that the signs ‘expected’ during Na deficiency have usually been derived from controlled experiments where all other nutrients are supplied to meet requirements.

There are nevertheless some field experiments where growth responses to Na (as NaCl) have been reported. Most comparable are those with sheep and cattle grazing lucerne grown on pumice soil in New Zealand (Joyce and Brunswick 1975). In these studies, Na in forage was similar to that in vegetative wheat crops and, as with grazing vegetative wheat crops, there were growth responses but no reports of craving for salt. As the concentrations of other elements in the lucerne were not reported, the possibility of an interaction between Na and other nutrients cannot be assessed. McClymont *et al*. (1957) also reported that the provision of NaCl improved feed intake and weight gain when wethers in poor condition were fed grain or a grain and roughage mix.

On the basis of these reports it can be concluded that Na deficiency may be a major contributor to the depression in growth but, still, other factors would appear to be involved.

Excess K is a further consideration within these experiments. Recently, Leiber *et al*. (2009) reported an association between high forage K and reduced neutral detergent fibre intake in dairy cows. The hay associated with this intake reduction contained 2.9% K, less than vegetative wheat forage. The Maximum Tolerable Level for ruminants as defined by the National Research Council is 3.0% (National Research Council 2005). Others have also reported a depression in feed intake when K is added to the diet (Suttle and Field 1969), with this reduction accentuated by low Na and Mg (Kunkel *et al.* 1953). These are isolated studies but nevertheless align well with the reduction in feed intake described in unsupplemented sheep grazing vegetative wheat crops (Dove and Kelman 2015*a*). Conversely, sheep and cattle commonly graze forages with 2–3% K with no reported ill effects; however, these pastures usually also contain adequate Na and Mg (Jacobs and Rigby 1999; Suttle 2010). The combination of high K together with low Na and Mg therefore requires further investigation.

In conclusion, the studies with mineral supplements for sheep grazing young dual-purpose wheat are important for having identified an apparent response or interaction between minerals that has not been previously characterised. Further research is now required to understand the nature and mechanisms of the interaction. This will best be approached through more intensive investigation of metabolic change within the grazing sheep.

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