Pasture Management Strategies for Reducing the Risk of Legume Bloat in Cattle

W. Majak*, J. W. Hall†, and W. P. McCaughey‡

Agriculture Canada, *Range Station, Kamloops, B.C., Canada V2B 8A9, Research Stations, †Vancouver, B.C., Canada V6T 1X2 and ‡Brandon, Manitoba, Canada R7A 5Y3

ABSTRACT: Results from two decades (1973-1993) of bloat research at Kamloops are reviewed. The trials were conducted with groups of ruminally fistulated cattle either grazing or fed daily fresh-cut alfalfa (Medicago sativa) herbage. Studies were conducted during the growing season (May to September) and in the fall (October and November). The alfalfa was usually in the vegetative to early bloom stages of growth. Visual assessments of bloat severity on a scale of 1 to 5 were made 0.5 to 2 h after feeding started, at which time ruminal cannulas were opened to relieve ruminal pressure. Every cultivar of alfalfa tested caused bloat, but sainfoin (Onobrychis viciifolia), birdsfoot trefoil (Lotus corniculatus), and cicer milkvetch (Astragalus cicer) did not. This confirms the bloat-safe features of these alternate legume forages. Bloat was positively associated with the level of Fraction 1 protein and total soluble protein in alfalfa, supporting the concept of a decreased probability of bloat with advancing stages of plant maturity. There was no association between alfalfa saponins and bloat. Prefeeding ruminal chlorophyll levels were higher and ruminal clearance rates were lower in cattle that were susceptible to bloat. Cattle that bloated on a given day consumed 18 to 25% less alfalfa immediately before bloat than non-bloaters did in the same time period. Ruminal cations were associated with bloat incidence but cation manipulation through supplementation did not prevent bloat. Of all the feed additives tested, only poloxalene (Bloat Guard®) completely prevented bloat. The occurrence of bloat was not associated with a simple, unique weather variable and it could persist after a "killing" frost. The claim that the risk of bloat may be reduced by waiting until the dew is off the alfalfa before allowing cattle to graze was substantiated. Bloat was observed from 2 to 17 times more often when cattle were fed between 0700 and 0800 than when they were fed 4 h later. The risk of bloat was also substantially lower when cattle grazed alfalfa continuously than when grazing was interrupted and cattle were allowed to graze for only 6 h daily. Pasture management systems that promote continuous and rapid ruminal clearance (more bypass, less gas) are most likely to reduce the incidence of bloat.

Key Words: Alfalfa, Bloat, Cattle, Clearance, Grazing Systems, Feed Additives

Introduction

The incidence of frothy bloat in cattle and sheep increases worldwide as legume forages gain popularity in cultivated pastures. This digestive disorder, often fatal, is a serious problem for livestock producers, especially in certain regions of western North America, eastern Australia, New Zealand, and parts of South America. Bulletins and handbooks on pasture management continue to extol the benefits of legume forages, but they also warn of the hazards associated with grazing bloat-inducing legumes, such as alfalfa and clover (Hanson et al., 1988; Thompson and Faull, 1990; Howarth et al., 1991). Various preconceptions and much anecdotal evidence have led to conflicting ideas about the causes, treatments, and predictions of bloat.

Bloat research with ruminally fistulated cattle at Kamloops, British Columbia, Canada has been designed to better understand the plant, animal, and microbial factors involved in the etiology of alfalfa bloat. Research facilities and techniques have been developed to effectively induce and assess the incidence of bloat. Chemical, climatic, and biological variables have been screened at Kamloops to determine their relationship to bloat. The efficacy of a number of feed supplements and additives for the control and prevention of bloat has also been tested.


This summary will briefly review the progress in bloat research at Kamloops from 1973 to 1993. Emphasis will be placed on research results with practical applications for pasture management of legume forages with a potential for bloat. This review will not cover the various attempts to select for and breed bloat-safe varieties of alfalfa or non-bloating breeds of cattle. For insight into these issues, the reader can refer to Rumbaugh (1985), Goplen et al. (1993), Howarth et al. (1986), Carruthers and Morris (1993), and Hall et al. (1994).

**Materials and Methods**

The trials were conducted with groups of ruminally fistulated cattle either grazed on alfalfa (*Medicago sativa*) pasture or fed harvested alfalfa cut daily. Studies were conducted during the growing season (May to September) and in the fall (October and November). The alfalfa was usually in the vegetative to early bloom stages of growth. The animals were cared for under the guidelines of the Canadian Council on Animal Care (1984). Visual assessments of bloat severity were made .5 to 2 h after feeding started, at which time ruminal cannulas were opened to relieve ruminal pressure. The severity of bloat was recorded on a scale of 1 to 5 by examining both the ruminal distension and the frothiness of ruminal contents: 1 = not frothy, no distension; 2 = frothy, no distension; 3 = distended on left side and release of frothy ruminal contents; 4 = distended on left and right sides and release of frothy ruminal contents; 5 = severe distension and exceptional release of ruminal contents when the cannula plug was removed.

In crossover trials, the length of each period was not specific but was determined by the total number of cases of bloat observed. Even when alfalfa is in early stages of growth most likely to cause bloat, the probability of bloat varies widely. The incidence of bloat can vary from year to year, from day to day, and on many days there may be no bloat. Consequently, if the period length was fixed, very little or no bloat might be observed in one or both periods and reliable inferences could not be made about the treatments. Determining the end of a period by the number of cases of bloat that occurred circumvented this problem. The cutoff of at least 24 cases per crossover period provided reasonable power for detecting treatment differences, and trials were usually completed in a few weeks' time. All the cattle were susceptible to bloat, as determined in previous trials, but none was a chronic bloater. Comparisons of the effects of the treatments on the occurrence of bloat were carried out using Cochrans' Q test (Cochran, 1950) that took into account the daily fluctuations in the bloat potential of alfalfa. Differences in alfalfa composition were tested using analysis of variance. A significance level of .05 was used throughout.

**Results and Discussion**

**Foaming Agents in Alfalfa**

Initially, the Fraction 1 (18S) theory of bloat was re-examined. Miltimore et al. (1970) had reported a high correlation between bloat and the concentration of the enzyme ribulose 1,5-biphosphate carboxylase oxygenase (Fraction 1) in alfalfa. This plant protein was considered to be the principle foaming agent. A 3-yr study (1973–75) showed, however, that Fraction 1 and other soluble protein fractions in alfalfa were only slightly associated with the occurrence of bloat. The conflicting results from the two studies were attributed to different methods of statistical analysis and to different extraction procedures (Howarth et al., 1977). In short, the predictive value of these protein fractions was poor, and soluble protein was a better indicator of bloat potency than Fraction 1. However, the positive association between bloat and protein fractions in alfalfa, which continued to be manifested in subsequent studies, supported the concept that the probability of bloat decreases with advancing stages of plant maturity. To maintain a high incidence of bloat at Kamloops, it was necessary to harvest the forage at vegetative to early bloom stages of growth. In addition, the risk of bloat was twofold greater when the forage height was < 25 cm than when it was > 50 cm (Howarth et al., 1991). It was also observed that the occurrence of bloat differed among years, but not among alfalfa cultivars or seasonal harvests (Howarth et al., 1977).

Next, the role of saponins in alfalfa bloat was re-examined using high- and low-saponin cultivars of alfalfa. The former had more than twice (1.94%, DM basis) as much saponin as the latter (0.82%) (Majak et al., 1980). Other workers (Lindahl et al., 1957) had implicated these triterpenoid and steroid glycosides as primary foaming agents in pasture bloat and the theory had gained wide acceptance (Cole and Boda, 1960; George, 1965). But, in spite of a twofold difference in saponin concentration between cultivars, there was no significant difference in the occurrence of bloat. We concluded that alfalfa saponins do not contribute to bloat by either the toxic or the foaming modes of action (Majak et al., 1980).

Every cultivar of alfalfa tested caused bloat (Howarth et al., 1991), but sainfoin (*Onobrychis viciifolia*), birdsfoot trefoil (*Lotus corniculatus*), and cicer milkvetch (*Astragalus cicer*) did not (Table 1), confirming the bloat-safe features of these alternate legume forages. The possible involvement of cinnamic acid conjugates in the etiology of legume bloat was also investigated. Daily feed samples of alfalfa were extracted with ethanol and the soluble phenolic compounds were screened by paper chromatography (Majak and Towers, 1973). A simple relationship between the levels of these alfalfa phenolics and the daily incidence of bloat was not established and the study was terminated (W. Majak, unpublished data).
Conditions in the Rumen That Lead to Bloat

In 1979 the focus changed from the search for bloat-causing compounds in alfalfa to studies on animal susceptibility to bloat. Ruminal contents were examined before alfalfa ingestion to determine ruminal and microbial factors that could predispose cattle to pasture bloat. Chlorophyll concentration, buoyancy of particulate matter, and rates of gas production were significantly higher in cattle that subsequently bloated than in those that did not. Higher prefeding chlorophyll concentrations when bloat occurred indicated the accumulation of suspended chloroplast particles in both the dorsal and ventral sacs of the rumen and in both the liquid and solid phase of ruminal contents (Majak et al., 1982, 1986a). This accumulation was consistent with a slower clearance rate from the rumen for animals that bloat compared with those that do not. In agreement with these observations, rates of passage of two water-soluble markers (Co-EDTA and Cr-EDTA) were slower in the more-susceptible animals in which the average half-life of the markers was 12 to 17 h. The average half-life was 8 h in the rumens of the less-susceptible cattle (Majak et al., 1986b). These results were obtained with cattle fed fresh alfalfa herbage but a slower ruminal clearance for cattle with a history of bloat could also be detected in other diets such as alfalfa hay, alfalfa pellets, and concentrate diets (Okine et al., 1989). These authors also showed that foam production in vitro was inversely correlated with fractional outflow rates of Co-EDTA. The authors concluded that higher foam production in bloat-prone cattle could be attributed to slower rates of passage of the liquid phase of ruminal contents. These combined results clearly indicate that the ruminal passage rate is an important factor in the etiology of legume bloat. Slower clearance enhances microbial activity and promotes gas production, which contributes to stable foam formation. Rapid clearance decreases microbial gas production, enhances protein bypass, and reduces the probability of bloat. The possibility of screening cattle for susceptibility to bloat using liquid rates of passage from the rumen was not pursued further.

Ruminal chlorophyll levels were also elevated and correlated with bloat when they were determined 2 h after feeding (Majak et al., 1985). In contrast, no relationship between bloat and the soluble protein content of ruminal contents was detected after feeding (Majak et al., 1985) even though the relationship was consistently present before feeding. Soluble protein in prefeding ruminal fluid was higher in animals that subsequently bloated than in those that did not (Hall et al., 1988). This persistent protein fraction was probably associated with the chloroplast particles that are relatively stable in the ruminal environment (Majak et al., 1986b).

During 1984–85, feed consumption of the animals was recorded before the first signs of bloat. In this time period, bloaters consumed 18 to 25% less alfalfa on average than non-bloaters (Hall et al., 1988). This result contradicted the old belief that the immediate cause of bloat is the gorging of the animal on succulent feed. Bloat is associated with a lower consumption of feed, not overfill. It is possible that early, subclinical signs of bloat (gastric distress) reduced feed intake.

Bloat Control with Supplements or Additives

The ruminal cation status was extensively examined in cattle fed fresh alfalfa and the concentrations of Na+ and K+ were found to be correlated with bloat. Bloat was associated with a low concentration of Na+ but a high concentration of K+. Levels of the divalent cations Mg+2 and Ca+2 were substantially lower but were also positively associated with bloat (Hall et al., 1988; Majak and Hall, 1990). These results suggested that manipulation of the cations through supplementation might provide a means of controlling bloat. However, Na+ supplements, with or without EDTA, which sequesters Mg+2 and Ca+2, were ineffective in the prevention of bloat (Hall and Majak, 1992). In agreement with these results, the incidence of bloat was not reduced when Na+ levels in white clover (Trifolium repens) pastures were increased with NaCl fertilizer (Carruthers et al., 1988).

It is well established that the ion equilibrium in the rumen can be manipulated by ionophores such as

---

### Table 1. The occurrence of bloat when non-bloating legumes were tested against alfalfa during 1982–85 (forage crude protein content [%], SD indicated in brackets)

<table>
<thead>
<tr>
<th>Species tested</th>
<th>Animal days per group</th>
<th>Bloat casesa</th>
<th>Alfalfa group</th>
<th>Test group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sanfoin</td>
<td>144</td>
<td>13</td>
<td>(19.5, 1.3)</td>
<td>(11.6, 1.1)</td>
</tr>
<tr>
<td>(Onbrychis vicifolia)</td>
<td></td>
<td>13</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Trefoil</td>
<td>102</td>
<td>(22.5, 2.6)</td>
<td>(16.9, 1.9)</td>
<td></td>
</tr>
<tr>
<td>(Lotus corniculatus)</td>
<td></td>
<td>26</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Cicer milkvetch</td>
<td>120</td>
<td>(18.4, 2.1)</td>
<td>(16.1, 2.0)</td>
<td></td>
</tr>
<tr>
<td>(Astragalus cicer)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

aBloat score of 3 or more.
monensin and lasalocid, which can alter cell membrane permeability and increase ion transport (Russell and Strobel, 1989). The efficacy of ionophores in the control of legume bloat was summarized by Hall and Majak (1989). In short, these feed additives, which are also antibiotics, reduced the incidence of bloat by more than 50% but they did not prevent the occurrence of legume bloat. Monensin was also effective in the control of bloat on winter wheat (*Triticum aestivum*) pastures (Branine and Galyean, 1990), and the authors concluded that the ionophore reduced frothiness by elevating ruminal pH, one of several ionophore effects in the rumen (Russell and Strobel, 1989). A monensin bolus is currently gaining widespread acceptance for reducing both the incidence and severity of legume bloat (Bagley and Feazel, 1989; Lowe et al., 1991; Cameron and Malmo, 1993; Merrill and Stobbs, 1993).

Household detergent (Tide®, which is commonly advocated as a bloat preventative, was ineffective, as were a commercial flocculant and a chromium supplement (Hall and Majak, 1992). In response to producers’ demands, we recently tested a commercial mineral mix (Silent Herder®) against poloxalene (Bloatguard®). Silent Herder® is widely used as a supplement in western North America and it is also promoted as a bloat preventative (Bachman et al., 1992; Hart, 1993). The supplements were given intraruminally at recommended dosages. Poloxalene eliminated bloat from the herd completely, but supplements of the mineral mix were only partially effective (Hall et al., 1994).

**Weather Conditions and Bloat**

Daily weather records from seven consecutive spring to summer growing seasons (May to September, 1976–1982) were examined to identify relationships between climate and pasture bloat. On average, days on which bloat occurred were preceded by lower maximum and minimum temperatures, but the temperature differences between days of bloat and no bloat were small (<2°C). On a daily basis, other weather variables including hours of sunshine, precipitation, and potential evapotranspiration were not significantly correlated with the occurrence of bloat (Hall et al., 1984). In the autumn, hours of sunshine and temperature range were greater on days when bloat occurred. On average, there was 1 h more sunshine and the temperature range was 1°C wider on days of bloat than on days of no bloat. In short, the occurrence of bloat was not associated with a simple, unique weather variable. Bloat was observed after “killing” frosts of 2.2°C in all years and even after a daily minimum of –9.6°C (Hall and Majak, 1991). The notion that alfalfa is bloat-safe after a frost is unfounded. In agreement with earlier studies (Howarth et al., 1977), total nitrogen and soluble nitrogen in alfalfa were higher on days when bloat occurred than when it did not (Hall et al., 1984; Hall and Majak, 1991).

**Feeding Regimens for Cattle Grazing Alfalfa**

Feeding regimens were examined in an attempt to minimize the occurrence of pasture bloat. The claim that the risk of bloat may be reduced by waiting until the dew is off the alfalfa before allowing cattle to graze was substantiated. Bloat was observed from 2 to 17 times more often when cattle were fed between 0700 and 0800 than when they were fed 4 h later (Majak and Hall, 1993). These results were observed in both grazing and feedlot trials. Ruminal chlorophyll was higher before the early feeding than before the late feeding. This suggested that feeding later in the morning reduced the predisposition of cattle to bloat by increasing particle clearance from the rumen (Majak and Hall, 1993). The risk of bloat was also substantially reduced when cattle grazed alfalfa continuously than when grazing was interrupted and cattle were allowed to graze for only 6 h daily (Table 2). Though statistical significance was not reached (*P* = .14), ruminal chlorophyll was lower under the 24-h regimen than under the 6-h regimen (W. Majak, unpublished data). These results agree with earlier studies on feeding regimens that showed a much lower incidence of bloat when alfalfa herbage (50 kg fresh weight-animal−1·d−1) was fed once a day than when it was fed twice a day for short periods in the morning (30 kg) and afternoon (20 kg) (Majak and Hall, 1990). One can envision an increasing probability of bloat with the following regimens: continuous (24 h) grazing; 6-h grazing or feeding once per day; 1 to 3 h grazing or feeding twice per day. The last regimen has been used extensively by other workers to induce bloat in grain-fed cattle and in cattle grazing legume or wheat pastures (Bartley et al., 1975, 1983). Pasture management systems that promote continuous and rapid ruminal clearance (more bypass, less gas production) are most likely to reduce the incidence of bloat.

**Table 2. Effect of feeding regimen on the incidence of bloat in cattle grazing alfalfa pastures during 1993**

<table>
<thead>
<tr>
<th>Crossover period</th>
<th>24 h</th>
<th>6 h</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of bloat casesb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sept. 7–14</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>Sept. 18–24</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>Totalc</td>
<td>5</td>
<td>41</td>
</tr>
</tbody>
</table>

*Two groups of four cattle grazed the same alfalfa pastures (var. 'Beaver') either continuously (24 h) or for 6 h daily.

bNumber of cases when bloat severity was rated 3 or more.

cDifference between treatments was significant (*P* < .001).
Implications

The risk of frothy bloat is reduced if 1) the legume has begun to flower, if 2) cattle are moved onto a new pasture in the afternoon, if 3) grazing is continuous and not interrupted, if 4) poloxalene is provided as a feed supplement, and, finally, if 5) the producer is aware that the bloat potential of alfalfa is not lost after a “killing” frost. Grazing systems that promote continuous and rapid ruminal clearance are most likely to reduce the occurrence of bloat.

Literature Cited


