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Bloat is an abnormal accumulation of gases in the paunch or rumen, resulting in great distention of the organ with subsequent paralysis of its walls. Bloat has been known for more than a century. Trotter of Scotland in 1811 writing on the general view of agriculture speaks of "the swelling of cattle by eating too great a quantity of clover, potatoes, turnips or cabbages." In recent years since legume pastures have become more widely used for dairy cattle, dairymen have become concerned about bloat.

The danger from bloat has been an important deterrent in more general use of legumes as pasture for dairy cattle. Dairy farmers recognize the importance of legumes for grazing. They know the carrying capacity, palatability and effect on the flavor of milk of legumes are satisfactory. Yet, the danger of losing animals from bloat has kept many from pasturing legumes.

Symptoms of Bloat. Most dairy farmers are familiar with bloat symptoms and rarely confuse this difficulty with diseases which may affect the herd. It may not be amiss, however, to discuss briefly the more obvious bloat symptoms so animals may be watched more cautiously and thus prevent loses.

Animals usually do not show symptoms of distress until the accumulation of gas causes the left side to appear full or distended. Frequently, the cattle continue eating until the pressure in the rumen, or paunch, is sufficient to cause distress and difficult breathing. In acute cases the rumen fills rapidly with gases, and the animals become distressed. Frequently they will bellow and stand with their mouths open, as though they were getting insufficient air, or as though breathing was very difficult.

When the distended condition of the rumen subsides, the animal may go back to grazing, indicating no apparent after-effects from bloat. In acute cases, whether the intra-ruminal pressure has been relieved by an opening in the rumen, or by other means, the animal indicates no serious after-effects such as attend many diseases, unless infection develops due to the opening in the rumen.

Cause of Death. It is generally accepted that bloat is due to the excessive accumulation of gases in the rumen. The cause of the excessive fermentation and subsequent accumulation of gases is not so well understood. Whether the gases result from bacterial, chemical, or enzymatic action in the rumen, or a combination of these factors is not known. It is assumed that as pressure due to gas in the rumen increases, pressure against the diaphram (muscular partition separating the cavity of the chest from the abdomen) becomes so great that it presses against the vital organs. Not only does it prevent normal breathing, but also normal heart action, and eventually results in death.

Conditions Conducive to Bloat. Surveys in this and other countries indicate considerable variation in experiences with bloat, particularly as to conditions which cause or are favorable to it. One point, however, on which there is universal agreement is that legumes are more likely to produce bloat than other plants. It is recognized, however, that other green plants, even silage and tubers, may produce bloat under certain conditions.

In a questionnaire answered by approximately 75 dairy farmers in South Dakota, there semed to be little difference of opinion on the effect of alfalfa and sweet clover in causing bloat. Experiences from farmers in other states seem to indicate that alfalfa is somewhat more likely to produce bloat than sweet clover or red clover. On the experimental pastures at the South Dakota Agricultural Experiment Station bloat was just as frequent on sweet clover as alfalfa pastures and just as serious when it occurred. In other words when cows bloated on alfalfa pasture, they also bloated on sweet clover pasture.

There does not appear to be very close agreement on the season, time of day, or atmospheric conditions when cows are more or less subject to bloat. Some farmers report that bloat is more prevalent early in the pasture season, while others report more danger from bloat in th cool fall nights. A few report more bloat in early morning, others late evening, and still others during the hottest part of the day. Some report more bloat when the plants are wet from dew or rain, and many farmers feel these conditions have no effect on bloat.

In a similar survey reported in Bulletin No. 127, from the West of Scotland Agricultural College, the replies from dairy farmers in Scotland were equally lacking in agreement.

Observations and experiences on experimental plots at the South Dakota Agricultural Experiment Station indicated greater danger from bloat early in the pasture season. During the last week or 10 days in May, and the first half of June, bloat was very serious in the years which it occurred.

Throughout the first five years no bloat was experienced on either sweet clover or alfalfa pastures. The first cases of bloat occurred on the experimental plots in the first week of September. The sweet clover and alfalfa plots had not been grazed during July and August because of lack of moisture. A heavy rain on September 3 accompanied by warm weather started a vigorous growth and in four or five days the alfalfa was 4 to 6 inches high. The cows were turned on the plot after the evening milking without thought of danger from bloat. The following morning three cows were found dead, and a number showed evidence of having been bloated. These were the only cases of bloat which were experinced in the fall of the year.

Observations at the South Dakota station when pasturing dairy cows on legumes seemed to indicate that greatest danger from bloat occurs when the plants are growing rapidly and therefore are more succulent and palatable. This usually occurs early in the pasture season. Temperature and rainfall usually are more favorable to rapid growth during late May and early June. As soon as dry, hot weather prevailed no further trouble from bloat was experienced. The survey reported in the West of Scotland College Bulletin. No. 127, also indicated greater danger from bloat during May and June, or the first part of the pasture season.

In surveys, farmers have reported bloat at all hours of the day. Some believe early morning when dew is on the plants is the most dangerous period, others reported the middle of the day, when heat was most intense, and others reported more trouble from bloat in the late afternoon and evening. Many found a warm day followed by rain or dew most favorable for bloat.

The past several years the cows on legume experimental plots at the South Dakota station seemed to bloat just before sundown. The cows would graze from early morning until time for evening milking with no apparent trouble. After the evening milking, usually completed by 6 p. m., the cows were turned to pasture. They usually stopped at the water tank on their way to the pasture and by 8:30 or 9 p. m. a number of cows would show marked symptoms of bloat.

Annual Variation in Occurrences. Bloat does not occur with equal severity every year. As stated previously, no difficulty was experienced with bloat for several years on the experimental plots at the South Dakota station. In the sixth year, the cows started to bloat. Pasture plots were the same and management of the cows had not changed, yet the cows bloated. This has also been the experience of dairy farmers in this and other countries. If the grazing area were changed to different parts of the farm, one might attribute the bloat experienced some years and not in others, to soil conditions, as many believe that bloat is more common on heavy than light soils. Naturally, a heavier, more vigorous plant grows on the better soils, and when moisture and other climatic conditions are favorable plants on these soils make a more rapid growth. However, in trials at the South Dakota station, the same plots were used and the management of the cows remained the same.

Short and Long Pastures. Observation on the South Dakota station plots seemed to indicate more danger from bloat when the plants were making vigorous growth. During this stage the herbage is more succulent and possibly contains a relatively higher percent of protein, inasmuch as the proportion of new to old growth is greater. Others have reported greater danger from short than from long pasture herbage, giving as a reason that the long herbage consists of relatively more fiber. This would not be true necessarily unless the plants are older as well as longer or taller. Maturity would in most cases add more to the fibrous condition of the plant than the size of the plant, and would therefore be a factor in preventing bloat.

Many dairymen take advantage of this factor by not pasturing alfalfa and sweet clover until the plants are approaching maturity. They report less bloat under these conditions. Others plan to cut the first crop of alfalfa and pasture the field thereafter. Because of the usual decreased rainfall later in the pasture season and consequently the slower growth of the herbage, undoubtedly the percentage of fiber is relatively higher then, than during the early part of the pasture season, when the plants are more succulent.

Susceptibility of Individual Cows. Observations of the cows on the experimental plots, indicated that some cows bloat more readily than others and that in large herds there may be several chronic bloaters. One explanation for this situation has been the more greedy appetite of some cows, and therefore the greater consumption of material to undergo fermentation and consequent

production of gases. It also is possible that some cows, from some inherent weakness of the digestive system or some temporary digestive disorder, are especially subject to bloat. Whatever the cause, observations of a large number of cows on legume pastures indicated that some cows bloat more easily and frequently than others subjected to the some conditions. This also is the experience of farmers who have observed cattle on legume pastures.

Kind of Gases in Rumen. For several years experimental work at the South Dakota station has been directed toward finding the cause of death from bloat. In experimental trials, an effort was made to determine the kind of gas produced, as it was felt this information might give some clue as to how gas was produced, and possibly as to its effect on the animal. Inasmuch as no experimental work had been reported on the type of gas produced when cows bloat on either alfalfa or sweet clover pasture, this problem was attacked.

Samples of gas have been obtained from bloated cows by means of a stomach tube. The tube was inserted in the gullet or esophogus of the cow, thence to the rumen. The intra-ruminal pressure resulting from the accumulation of gases was sufficient to force the gases through the tube and into a collapsable rubber gas-bag, or glass tube which was provided with stoppers, so the gas could be held until analyzed.

Gas Analyses[1]

	No. of Samples	CO_2	Ill.[2]	O_2	H_2	CO	C_2H_6	CH_4	N_2
Trial 1	9	61.97	0.12	3.60	0.31	0.44	0.09	15.30	18.20
Trial 2	6	60.74	0.04	2.79	9.36	0.17	0.00	0.14	26.18
Trial 3	1	59.80	0.00	3.61	0.05	0.05	0.00	18.42	18.07
Trial 4	12	53.49	0.05	1.53	26.51	0.20	0.05	0.05	18.11
Trial 5	7	52.65	0.22	2.54	24.81	0.13	0.00	0.00	19.65
Trial 6	5	58.64	0.14	0.80	34.58	0.08	0.00	0.08	5.68
Trial 7	2	18.30	0.15	9.83	7.16	0.18	0.00	0.00	64.38
Trial 8	1	25.30	0.35	0.93	14.35	0.58	0.00	0.00	58.59
Trial 9	1	24.66	0.00	3.64	4.24	0.50	0.00	0.00	66.96

Trial 1—Gas Analysis From Cows Bloated on Sweet Clover
Trial 2—Generated Gas From Sweet Clover Plants
Trial 3—Gas Analysis From Cows Bloated on Alfalfa
Trial 4—Generated Gas From Alfalfa Plants
Trial 5—Generated Gas From Sudan Grass Plants
Trial 6—Generated Gas From Sorghum Plants
Trial 7—Generated Gas From Corn Plants
Trial 8—Generated Gas From Marsh or Low-land Grass
Trial 9—Generated Gas From Brome Grass

1. The author is indebted to Messers Allen Evans and Leland Manley for conducting the analyses, and to Dr. G. C. Wallis for suggestions on setting up the gas analysis apparatus.
2. Ill.—Illuminants.

A number of gas samples were collected by inserting a trocar into the ruman or paunch of cows which had died from bloat. In some instances these cows had been dead from 24 to 36 hours. The gas was collected and held until analyzed, in the same manner as when the gas was collected via the stomach tube.

Gas was generated from legumes and non-legume plants under laboratory conditions. The plants were collected at different times of the day as well as different seasons to note any differences which might occur in percent of the different gases in these plants. Inasmuch as cows seemed to bloat more fre-

quently during the early part of the pasture season, and after sundown, it was thought that perhaps the kind of gases produced at these times also would vary.

The gas from bloated animals as shown in Trials 1 and 3 indicate a relatively high percentage of carbon dioxide and methane and only traces of carbon monoxide. Oxygen, hydrogen and nitrogen are present in the inspired air or the air which animals normally breathe and therefore are not harmful to the animal except as these gases may be factors in causing the excessive pressure in the paunch when animals bloat.

The analyses of gases from sweet clover and alfalfa bloat in Trials 1 and 3 show no significant differences. The small difference which does obtain can be explained on the limited number of samples analyzed, as well as on the possibility of contamination of the samples with air.

There seems to be no significant differences in the gases produced from alfalfa and sweet clover plants when these gases are generated under laboratory conditions as shown in Trials 2 and 4. The greatest difference occurred in hydrogen, which probably is not signficant so far as bloat is concerned as this gas is present in the air we breathe. Inasmuch as nitrogen is obtained by difference it would vary in percent according to the total of the other gases. Nitrogen is also a part of the air we breathe.

The gas analyses reported in Trials 2, 4, 5, 6, 7, 8 and 9, from legumes and non-legume plants, show no significant differences in kind of gases present. The percent of carbon dioxide in the corn plant, low-land grass and brome grass appear to be appreciably lower than in the legumes. Because of the relatively few samples analyzed a definite conclusion can not be based on this difference.

The analyses reported in Trials 1 and 3 on the kind and percentage of gases found when animals bloat from sweet clover or alfalfa contain two gases which are toxic or poisonous. They are carbon dioxide and carbon monoxide. These gases also are present in non-leguminous plants such as the corn plant and the grasses, which rarely cause bloat under normal conditions.

Other workers have reported hydrogen sulphide in the rumen gas. (No test was made for this gas in the reported South Dakota station analyses.) This gas is highly toxic, and is fatal to animals in concentrations as low as 0.1 percent, according to authorities on toxicology. When this gas is diffused in the systemic blood it acts through the tissues, especially the lungs. Hydrogen sulphide produces labored breathing, pains in the stomach, and in concentrations of 0.2 percent (that is 2 volumes of gas to 1,000 volumes of blood) it paralyzes the respiratory center. Hydrogen sulphide gas is also present in gases of the animal when it is not bloated. Probably the reason it has no harmful effects under normal feeding conditions is that it is excreted through the normal excretory channels.

It is understood by those who have worked with bloat and also is stated in textbooks on the subject, that death when animals bloat, is due to the excessive intra-ruminal pressure. This pressure is assumed to be so excessive that the normal function of the lungs and heart is inhibited, and death is due to suffocation. Some have reported that the pressure is great enough to actually burst the paunch.

The toxic gases in the rumen gas may play an important role in the cause of death from bloat. Hydrogen sulphide, carbon monoxide and carbon dioxide affect respiration, and as a consequence the animal may suffocate for lack of oxygen. The gases may be absorbed directly from the rumen, and diffused in the systemic blood of the animal. The reason toxic gases are absorbed and not excreted through the normal excretory channels as under normal conditions, may be due to the excessive intra-ruminal pressure, which follows the excessive fermentation in acute bloating. The intra-ruminal pressure may paralyze the rumen. When this happens the peristaltic movements of the rumen or the churning action of this organ are inhibited and the gases cannot be eructed or belched as under normal conditions, neither can the gases escape through the excretory channels. The intra-ruminal presure may therefore be an important factor in causing the absorption of the gases from the rumen.

If the foregoing hypothesis is correct the cause of death from bloat is the diffusion in the systemic blood of the toxic gases and not from the excessive intra-ruminal pressure and its effect on the normal functioning of the heart and lungs.

Prevention and Treatment. Many suggestions for the prevention of bloat have been proposed. These bloat prevention measures are based largely on experiences and observations. They seem to be effective under some conditions, but useless under others. One of these bloat preventive measures is to give the cows an ample feed before turning them on the pasture. The purpose of feeding before turning on pasture is to keep the cows from eating the succulent legumes too greedily as well as from eating too much.

Another bloat preventive measure frequently suggested, is to make available some form of dry roughage to cows and on legumes pastures. It is believed that when cows are eating succulent legumes, they crave some form of dry roughage. The dry roughage will fill the paunch with more or less fibrous material, thus decreasing consumption of sweet clover or alfalfa, and thereby diminishing fermentation.

Some have found that salt and minerals, particularly lime, kept before the cows while on legume pastures lessen the danger from bloat. The addition of lime or baking soda to the drinking water is recommended as a bloat preventive measure by others.

If cows do not have ready access to water so they can drink frequently, the danger from bloat is increased, experiences of some observers woudl indicate. If cows drink only in the early morning when turned on pasture and in the evening when taken off, they consume too much water at one time. This increases fermentation, and fills the paunch with gas and water.

Many farmers have experienced greater danger from bloat when legume pastures are wet from rain or dew. Some farmers feel that when the legumes are frosted bloat danger is increased.

The foregoing measures have been checked at the South Dakota station with cows on sweet clover and alfalfa pastures. During one pasture season when bloat was especially bad, the cows bloated so frequently it was necessary to have a man watch them continually. These so called preventive measures were tested but proved of little avail.

The cows were watered four times during the 10 hours they were on pastures, and still they bloated. Baking soda was also added to the water with no noticeable beneficial effect in preventing bloat.

A load of choice alfalfa hay was placed in a sweet clover plot. The cows ate sparingly of the hay, but it did not prevent them from bloating. It was not possible to determine if it decreased the probability of bloat. However, it did not prevent some cows from bloating. Steam bone meal and salt were kept continuously before the cows in well-protected boxes. The cows licked at both, but it did not prevent them from bloating.

Experiences with bloat on pastures wet with dew or rain indicated that neither had any noticeable effect on inducing bloat. Dr. A. J. Schalk of the Ohio station, reports in Bulletin No. 548, that he tried many of these so-called preventive measures under controlled experimental conditions and arrived at the conclusion that these so-called preventive measures had no perceptible influence on the fermentation of the contents of the rumen or paunch.

The fact that the experiences and observations of a large number of dairymen differ so widely and their recommendations for the prevention of bloat are so divergent is evidence that these measures are not infallible. Some of these measures may be successful in preventing bloat under certain conditions and worthless under other conditions. It means, therefore, that dairymen cannot afford to take the risk that one or more of these preventive measures will prevent bloat.

Treatment of bloat depends upon its severity. In mild forms, in which the left side of the animal becomes distended beyond normal size, the gas may be released by merely placing a wooden stick, or gag, in the cow's mouth. A bridle bit will have the same effect. The purpose of the stick or bit is to get the animal to belch, and thus expel the accumulated gas in the rumen. It is well to have the animal stand with the front feet higher than the rear feet. The rumen ingesta will then flow to the lower side of the rumen permitting the gas to accumulate in the upper part of the rumen, and therefore closer to the esophagus or gullet, where it can be belched.

A long rubber tube can be inserted into the rumen, which affords a means for the gas to escape. Again it is well to have the animal stand with the front feet higher than the rear.

The Nuesch stomach tube is an aluminum tube about 6½ feet long, the end that enters the stomach consists of a flexible piece 5 inches long which turns upward when meeting any obstruction. This prevents the end that enters the stomach from filling with rumen contents. It functions like the rubber tube in releasing the gas.

A number of medicinal remedies, are effective in mild cases of bloat. The purpose of these is to inhibit fermentation and allow the gases already formed to escape through normal excretory channels. A few of these home remedies are:

2 ounces of turpentine in 1 quart of milk—given as a drench
2 ounces of kerosene in 1 quart of milk—given as a drench
½ ounce of formalin in 1 quart of water—given as a drench
1 ounce bicarbonate of soda—given as a drench

In severe cases of bloat, if the rumen fills rapidly with gas and it becomes difficult for the animal to breathe, the only remedy is to puncture the rumen

and release the gas. In extremely severe cases the fermentation is so vigorous that a small opening such as is made with a trocar fills immediately with the rumen contents, obstructing any further escape of gases. Then the only thing to do is to make a large enough opening so that the gases can escape. It may even be necessary to remove some of the rumen contents to stop fermentation and the subsequent formation of gases. It is necessary, of course, to prevent infection in the incision made through the skin and rumen.

Summary

1. Bloat, hoven or tympanitis effects cows and sheep but rarely non-ruminants, such as horses and hogs.
2. The symptoms are a very marked distension of the left side of the animal. In severe cases the left side of the rumen extends over the topline.
3. No experimental data are available to indicate what factors definitely induce bloat. Numerous surveys made in this and other countries on factors which induce bloat show that the experiences and observations of practical farmers are not in agreement. About the only point on which they agree is that there is more danger from bloat from legumes than from grasses.
4. It has been known for some time that gases are produced in the rumen or paunch. In the cases of bloat the volume of gas produced is greatly increased. It is assumed that intra-ruminal pressure is increased to a point that it interferes with the normal functioning of the heart and lungs.
5. The rumen gas contains several toxic gases. Two of these, carbon monoxide and hydrogen sulphide, are toxic or poisonous in very small quantities when diffused in the blood.
6. It is possible that intra-ruminal pressure when it reaches a given point, paralyzes the rumen, preventing peristalsis or the normal churning action of the paunch and liberation of the gases. When these toxic gases are absorbed from the rumen and diffused in the systemic blood, death may result from asphyxia or suffocation.
7. No infallible bloat preventive measures have been discovered. Some measures are effective in some cases under certain conditions, while under what may appear to be similar conditions, these same measures do not prevent bloat.
8. In mild cases of bloat the gases can be released from the rumen by means of a gag which will induce belching.
9. Some remedies like turpentine, kerosene or formalin in milk or water may check or even stop the fermentation, and effect a release of the gases produced.
10. In acute cases of bloat, or the "boiling type," the gas must be released by puncturing the rumen. It sometimes is necessary to remove part of the rumen contents to check fermentation.