UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Service
Office of Administrator
Washington 25, D. C.

March 2, 1956

TO : Participants in Conference on Rumen Function

FROM : H. W. Marston, Research Coordinator, Agricultural Research Service, U.S.D.A., Washington 25, D. C.

SUBJECT: Report of Conference

Attached is a copy of the notes of the third Conference on Rumen Function, held at the Congress Hotel, Chicago, Illinois, on November 30 and December 1, 1955, and a list of persons in attendance during the two-day meeting.

At the close of this Conference the group agreed that a similar conference should be held in 1956, and that the same approximate time and place for the conference was satisfactory. It was also agreed that the same panel chairmen should be continued, or that they arrange for a successor. The chairmen of the various panels are to be complimented for their work in arranging a most interesting series of discussions.

The Conference convened at 9:30 AM on November 30, 1955.

Attachments

REPORT ON
CONFERENCE ON RUMEN FUNCTION
held at
Congress Hotel, Chicago, Illinois
November 30-December 1, 1955

The following persons were in attendance during the two-day meeting:

NAME	ORGANIZATION
Upson S. Garrigus	Illinois Agri. Expt. Sta., Urbana, Illinois
A. L. Neumann	Illinois Agri. Expt. Sta., Urbana, Illinois
E. E. Hatfield	Illinois Agri. Expt. Sta., Urbana, Illinois
Hugo O. Graumann	Plant Industry Sta., USDA, Beltsville, Md.
Kling L. Anderson	Kansas Agri.,Expt. Sta., Manhattan, Kansas
E. A. Hollowell	Plant Industry Sta., USDA, Beltsville, Md.
Raymond Borchers	Nebraska Agri. Expt. Sta., Lincoln, Nebraska
C. R. Thompson	Western Utilization Research Branch, USDA, Albany, California
A. L. Neal	N. Y. Agri. Expt. Sta., Cornell University, Ithaca, New York
W. K. Kennedy	N. Y. Agri. Expt. Sta., Cornell University, Ithaca, New York
Melvin J. Swenson	Kansas Agri. Expt. Sta., Manhattan, Kansas
H. D. Jackson	Indiana Agri. Expt. Sta., Purdue University Lafayette, Indiana
G. D. Goetsch	Indiana Agri. Expt. Sta., Purdue University, Lafayette, Indiana
W. R. Pritchard	Indiana Agri. Expt. Sta., Purdue University, Lafayette, Indiana
Roy S. Emery	Dairy Dept., Michigan State University, East Lansing, Michigan
Marvin P. Bryant	Dairy Husbandry Research Branch, USDA, Beltsville, Maryland
Ray E. Ely	State Experiment Stations Division, USDA, Washington, D. C.
N. R. Ellis	Animal & Poultry Husbandry Research Branch, USDA, Beltsville, Maryland
E. J. Warwick	Animal & Poultry Husbandry Research Branch, USDA, Beltsville, Maryland
R. B. Grainger	Kentucky Agri. Expt. Sta., Lexington, Kentucky
L. B. Embry	South Dakota Agri. Expt. Sta., Brookings, South Dakota
W. E. Thomas	North Carolina Agri. Expt. Sta., Raleigh, North Carolina
R. E. Davis	Animal & Poultry Husbandry Research Branch, USDA, Beltsville, Maryland
O. E. Sell	Georgia Agri. Expt. Sta., Experiment, Georgia
H. H. Cole	California Agri. Expt. Sta., Davis, California
J. C. Thompson	Ralston Purina Co., St. Louis, Missouri
Joseph T. Blake	Iowa State College, Ames, Iowa

NAME	ORGANIZATION
N. L. Jacobson	Iowa Agri. Expt. Sta., Ames, Iowa
L. C. Payne	Iowa Agri. Expt. Sta., Ames, Iowa
R. W. Dougherty	N. Y. State Veterinary College, Cornell University, Ithaca, New York
Clarence H. Thompson, Jr.	State Experiment Stations Division, USDA, Washington, D. C.
W. E. Dinusson	North Dakota Agri. Expt. Sta., Fargo, N. D.
Howard W. Johnson	Animal Disease & Parasite Research Branch, USDA, Beltsville, Maryland
William B. Hardie	Chas. Pfizer & Co., Terre Haute, Indiana
Clair E. Terrill	Animal & Poultry Husbandry Research Branch, USDA, Beltsville, Maryland
R. E. Nichols	Wisconsin Agri. Expt. Sta., Madison, Wisconsin
W. E. C. Moore	Virginia Agri. Expt. Sta., Virginia Polytechnic Institute, Blacksburg, Virginia
W. L. Boyd	Minnesota Agri. Expt. Sta., St. Paul, Minn.
C. K. Whitehair	Chas. Pfizer & Co., Terre Haute, Indiana
W. T. Oglesby	Louisiana Agri. Expt. Sta., Baton Rouge, La.
C. F. Huffman	Michigan Agri. Expt. Sta., East Lansing, Mich.
J. M. Scholl	Iowa Agricultural Expt. Sta., Ames, Iowa
George A. Montgomery	Capper Publications, Topeka, Kansas
J. A. Jackobs	Illinois Agri. Expt. Sta., Urbana, Illinois
Carl N. Hittle	Illinois Agri. Expt. Sta., Urbana, Illinois
Earl C. Spurrier	Illinois Agri. Expt. Sta., Urbana, Illinois
George F. Snell	Plant Industry Sta., USDA, Beltsville, Md.
Richard E. Brown	Illinois Agri. Expt. Sta., Urbana, Illinois
Willard O. Nelson	Illinois Agri. Expt. Sta., Urbana, Illinois
Roland A. Gessert	Vet. Med. Branch, Food & Drug Administration, Washington 25, D. C.
Don R. Jacobson	Dairy Dept., Uni. of Maryland, College Park, Maryland
Clyde K. Smith	Michigan Agri. Expt. Sta., East Lansing, Mich.
R. H. Roethke	Union Starch & Refining Co., Columbus, Indiana
P. F. Anderson	Northern Utilization Research Branch, USDA, Peoria, Illinois
G. K. Underbjerg	Kansas Agri. Expt. Sta., Manhattan, Kansas
A. F. Sellers	Minnesota Agri. Expt. Sta., St. Paul, Minn.
Harry W. Cowin	California Agri. Expt. Sta., Davis, California
Ivan L. Lindahl	Animal & Poultry Husbandry Research Branch, USDA, Beltsville, Maryland
L. Meyer Jones	Iowa Agri. Expt. Sta., Ames, Iowa
B. T. Simms	Agricultural Research Service, USDA, Washington, D. C.
Cecil Elder	Missouri Agri. Expt. Sta., Columbia, Missouri
M. J. Twiehaus	Kansas Agri. Expt. Sta., Manhattan, Kansas
B. F. Barrentine	Mississippi Agri. Expt. Sta., State College, Mississippi
A. E. Dracy	South Dakota Agri. Expt. Sta., Brookings, South Dakota

NAME	ORGANIZATION
W. D. Pounden	Ohio Agri. Expt. Sta., Wooster, Ohio
R. G. Hansen	Illinois Agri. Expt. Sta., Urbana, Illinois
C. E. Stevens	Minnesota Agri. Expt. Sta., St. Paul, Minn.
R. S. Sugg	Alabama Agri. Expt. Sta., Auburn, Alabama
W. H. Bennett	Utah Agri. Expt. Sta., Logan, Utah
H. W. Marston	Agricultural Research Service, USDA, Washington, D. C.

For the purposes of discussion, the program was divided into panels. The identification of the panels and the chairman of each was as follows:

(a) Microbiology - Dr. W. D. Pounden
(b) Physio-Pathology - Dr. R. W. Dougherty
(c) Agronomic - Dr. W. K. Kennedy
(d) Rumen Physiology - Dr. C. F. Huffman
(e) Animal Management - Dr. H. H. Cole

MICROBIOLOGY PANEL

Observations on Experiment Rations Used to Induce Frothy Bloat - Clyde K. Smith, Michigan State College

The following bloat producing rations have been fed to intact and rumen fistula animals to reduce the amounts of naturally occurring plant materials in the diet. These rations were compounded following the pattern of Smith et al (1) and fed at the rates of 18 to 24 pounds of concentrate and 2 to 4 pounds of hay for mature cows. In the case of the corn and soybean oil meal ration, 40 pounds per day was fed early in lactation.

TABLE I

Rations*	Relative Severity of Bloat
Corn + S. B. O. M. + Hay	####
Corn Gluten Meal + Hay	###
Corn Starch + S. B. O. M. + Hay	###
Corn + S. B. O. M.	####
Corn + Urea + Hay	####
Corn + Urea	###
Corn + Hay	##
Corn + Cellophane	##

* All of above rations contain a mixture of $CaHPO_4$ 1.0%; $CaCO_3$ 1%; NaCl 1%; Vitamins A, D, and Cobalt.

The time of onset of bloat after starting a ration varied with the individual animals and the type of ration. The shortest onset being 4 days with the corn, soybean oil meal and hay ration and the longest being 145 days, when the hay was not included. It was observed that the froth was more stable when the soybean oil meal was included and that rations of corn or corn and urea tended to produce a large bubble froth. Some animals were prone to bloat before feeding in the morning, and others would bloat late in the evening, 4 to 6 hours after feeding. Identical twins on the same ration exhibited similar bloating patterns.

1. Smith, C. K., J. R. Brunner, C. F. Huffman, and C. W. Duncan, Experimental Production of Frothy Bloat in Cattle. J. Animal Sci. 12:932, 1953. (Abst.).

The Cause of and Biochemical, Physical, and Bacteriological Factors Related to Uncomplicated Frothy (Feed Lot) Bloat - Don R. Jacobson, J. C. Shaw, G. H. Beck, J. J. McNeill and R. N. Doetsch, University of Maryland

A new appraoch to the problem of feed lot bloat in cattle is described. Bloat has been classified as being of the free-gaseous and frothy types. In this study emphasis has been placed on production and study of frothy bloat. The studies include physical measurements of rumen contents, changes in bacterial metabolism, and volatile fatty acid and lactic acid composition of samples of rumen contents taken from cattle fed in dry lot under controlled conditions. Data for this paper were taken from more than 800 fatty acid analyses, a portion of them on rumen fluid and a portion of them on dissimilation fermentation liquor. These analyses involved over 200 rumen samples taken from 15 cattle. The bloat producing diet employed in these studies consisted of 61% barley, 16% soybean oil meal, 1% NaCl, and 22% alfalfa meal.

After removal from the rumen, the rumen contents from cattle on the bloat producing diet, increased in volume with time. This increase was due apparently to the entrapment of small bubbles of gas throughout the rumen contents. Since it appeared that this could be of considerable importance as a causative factor in bloat, rumen samples were drawn from a number of animals on the bloat producing diet and measurements obtained. The term, "Ingesta Volume Increase" (IVI) is used to define these measurements. In order to measure the IVI, an aliquot (200 ml.) of freshly drawn rumen contents was placed in a 500 ml. graduated cylinder and held in a constant temperature bath (39^{o}) for a period of one hour, after which the increase in volume was recorded in per cent. The IVI represents an attempt to measure the rate of total froth production of rumen contents.

The average IVI of 16 rumen samples, taken by stomach tube from six animals at two hours after feeding the bloat producing diet was 94, which means that the final volume was 194 per cent of the original. The diet of the same six animals was later changed to two parts alfalfa hay and one part bloat producing mix. After approximately two weeks on this diet, when the animals were not bloating, 13 rumen samples were again obtained at two hours after feeding. The average IVI of these samples was 67. This difference with change in diet was significant and indicates that total froth production is associated with bloat. At an average IVI of 67, the animals apparently had not returned to normal, because the IVI values on ordinary non-bloat producing diets ranged from 0 to 40, and averaged about 20.

Even though the rumen contents of the animals on the bloat producing diet were consistently frothy, bloating was intermittent, indicating that the presence of froth alone does not insure bloat. During the one hour incubation period, the froth formed in some samples contained large bubbles and collapsed of its own weight, whereas the froth formed in other samples contained small bubbles and remained very stable. Since it appeared obvious that the stable froth would be more conducive to bloat, a technique was devised for measuring the stability of the froth formed during the one hour incubation period. Two hundred ml. of rumen contents were placed in a 500 ml. graduated cylinder and incubated one hour. The contents of the graduate were then stirred 12 times around the full depth of the cylinder and the final volume obtained. The value recorded was the per cent increase or decrease of the original volume. This value was termed the Stable IVI and represents an attempt to measure the rate of stable froth formation of rumen contents. The Stable IVI values obtained from cattle at a variable time after feeding the bloat producing diet ranged from 0 to 72 and averaged 22 for 10 rumen samples. The same rumen samples gave IVI values that ranged from 12 to 75 and averaged 49. The low IVI and Stable IVI values occurred at 6 to 8 hours after feeding.

The addition of glucose to a portion of the same rumen samples increased the average Stable IVI from 22 to 45. The addition of both glucose and saponin increased the average Stable IVI to 88. Glucose serves the primary function of providing a readily available source of energy to the rumen microorganisms. Rapid fermentation is necessary for a high rate of gas formation or a high IVI. Saponin, on the other hand, serves to stabilize the total froth produced. Glucose and saponin together have an effect, which is more than additive, on the production of stable froth. It was also noted that valeric acid could contribute to the formation of stable froth.

Four animals of approximately 800 lbs. each, that had been receiving corn silage and mixed grass hay ad lib., were placed on a diet of five lbs. of mixed grass hay and six lbs. of the bloat producing mix for four weeks, then gradually over a 10 day period changed to 14 lbs. of the bloat producing diet daily for 74 days. Rumen samples were taken at various weekly intervals and subjected to physical, biochemical, and bacteriological treatments and analyses. In summarizing the results, it may be pointed out that the bloat index increased from 2 at week 6 (the first week on the bloat producing diet) to 13 at week 16. All four animals bloated, some much more than others. The per cent of rumen contents which separated out into a liquid phase in one hour gradually decreased from 45 to 21 to 0 at weeks 0, 6, and 16 respectively. This indicates that there was a marked change in the physical nature of the rumen contents over a 10 week period when the animals were on a constant intake of the bloat producing diet. Heretofore, it has not been recognized that such a phenomenon exists. The dry matter content of the rumen samples ranged from 8.4 to 11.2 per cent. The degree of encapsulation of the rumen bacteria when the animals were on the bloat producing diet was very high. At week nine, 49 per cent of the rumen bacteria were heavily encapsulated. The degree of encapsulation gradually increased to 71 per cent at week 16. Here is evidence that the bacterial morphology actually continued to change for an appreciable period of time after the animals were changed to a new diet (bloat producing). It is postulated that the production of so-called "slime", which is believed to be closely associated with the high degree of encapsulation of the rumen bacteria, contributes to stable froth formation.

When the animals were on the bloat producing diet, lactic acid and an iodine staining substance was always present in the rumen fluid, whereas a reducing substance was never present. Each rumen sample was analyzed for its volatile fatty acid content. In addition, bacteria were obtained from the same rumen samples by differential centrifugation and subjected to the cell suspension technique for the dissimilation of 600 micromoles of glucose and cellobiose in separate flasks. The resultant fermentation liquors were analyzed for residual substrate, lactic acid, ISS, and volatile fatty acids. In the rumen fluid, the proportion of the various volatile fatty acids changed as the diet was changed, and in the case of the bloat producing diet, changed with time on the diet. On the hay and silage diet (week 0) the ratio of acetic, propionic, and butyric acids was roughly 6:2:1. After four weeks on 5 lbs. of mixed grass hay and 6 lbs. of the bloat producing mix (week 4), the ratio was altered to approximately 7:1:1. On the bloat producing diet the actual percentage of each acid gradually changed from 55:21:21 to 46:29:18 to 60:19:15 at 4, 39 and 74 days respectively. These changes for acetic and propionic acid were significant and indicate that there was a changing situation in the rumen. Equilibrium, in terms of fatty acid composition in the rumen, was not reached in a few days, as would be expected, but continued to change for a period of 74 days. It is not know whether the above changes in fatty acid composition in the rumen reflect changes in actual production of these acids, or in absorption of these acids from the rumen, or both. Neither is it known what influence these changes had on the occurrence of bloat, although there was an increase in the bloat index and valeric acid content in the rumen during the second week on the bloat producing diet.

When the cattle were on the bloat producing diet, the actual percentages of acetic, propionic, and butyric acids that resulted from the dissimilation of cellobiose changed from 50:36:12 to 21:50:19 to 41:34:20 at 4, 39, and 74 days respectively. Changes in the rumen fatty acid ratio were reflected in an accentuated manner in the fatty acid ratio resulting from the dissimilation of cellobiose. It may be that the dissimilation of glucose and cellobiose gives a more accurate picture regarding actual production of fatty acids in the rumen than the analyses of rumen contents alone can give. The fatty acid ratio from rumen microbic dissimilation of cellobiose changed with each diet and, in the case of the bloat producing diet was constantly changing for a period of 74 days. The dissimilations were run in the same manner each week. Therefore, provided the technique is valid, it can only mean that the metabolic activity of the rumen microorganisms did not reach an equilibrium quickly, but was constantly changing for at least 74 days following placement of the animals on the bloat producing diet. It is not known whether this relfects a change in numbers of bacterial species, or a change in the physiological behavior of the species already present, or both. Heretofore, it has not been recognized that the rumen microorganisms from animals on a constant diet could exhibit such variable metabolic acitivity.

Stable Foam and Gas Production Capacities of Pasture Plant in vitro,
W. D. Pounden, A. Hahn, H. R. Conrad, T. V. Hershberger, and O. G. Bentley, Ohio Agricultural Experiment Station

Two in vitro tests were used to estimate the relative foam capacity of plant tissues and ability of the tissues to support a stable foamy mass. Limited use was made of a third test for measuring the relative speed with which gas was evolved by rumen juice to which was added plant tissues.

Foam Capacity: Plant tissues were passed through a Hobart food chopper, 25 gm. placed in a Waring blender having volume graduations on it with 150 ml. of water and beaten for 1 minute. The mixture was squeezed in cheesecloth, 150 ml. of the liquid put in a clean blender and beaten for 5 seconds. A minute later the reading was made of the quantity of foam present.

Tests were conducted weekly or more often throughout the season. There was considerable foam capacity in all the plants examined at all times, both grasses and legumes with alfalfa giving the highest figures. The results obtained for alfalfa from bloat producing pastures did not differ from the non-bloat producing ones.

Stable Foamy Mass Capacity: This test was designed to measure the ability of plant to simulate the stable foamy mass composition of rumen contents from bloated animals.

Plant tissues were processed by chopping up as for the foam test. These were gradually added to water in a Waring blender accompanied by beating until a stable homogenous gassy mass was produced. The "end-point" was a stability approximating that encountered in rumen samples obtained from bloated animals. These masses after standing 5 minutes or more were capable of holding the excess liquid in place when the lender cup was tilted over considerably, sometimes even up to a 45° angle.

Stable foamy masses were produced using samples of alfalfa collected weekly or more often during the season from the pastures being grazed or ones of similar age. It was possible to produce similar stable masses from ladino clover but not from birdsfoot trefoil, brome or orchard grass. In the case of the latter 3 plants, the masses became stiff as higher quantities of plant tissues were aded but they were not homogenous.

Gas Production Capacity: The quantity of gas produced during an hour of incubation by mixtures of rumen juice and plant tissues was measured. More gas was collected from alfalfa and ladino clover than orchard grass and birdsfoot trefoil using rumen juice from cows on legume-grass pasture, on dry feed, and from bloated animals.

Thus all 3 of the methods, foam, stable foamy mass, and gas production capacity tests for measuring in vitro relative ability of pasture plants to contribute to some of the factors which may be connected with bloat gave similar results. Alfalfa and ladino clover had greater capacities than birdsfoot trefoil, orchard or brome grass.

Sustitution of rumen juice from either animals on pasture or dry feed for the water used in the foam capacity and stable mass tests failed to change the results. From this it was concluded that the rumen juice samples did not contain any foam or foam stability reducing agents.

It was possible to form stable foamy masses using washed fiber from alfalfa mass tests beaten into alfalfa-water liquid from a similar source. This was possible even after the liquid had been heated to 80°C and much of the solids precipitated out and discarded.

Bloat on Two Types of Legume-Grass Pastures, A. D. Pratt, R. R. Davis, W. D. Pounden, and H. R. Smith, Ohio Agricultural Experiment Station

In conjunction with experiments being conducted on pastures for dairy cattle it was possible to compare the incidence of attacks of bloat on two kinds of pastures. One pasture was composed of alfalfa, ladino clover and brome grass and in the other orchard grass replaced the brome. The physical layout of the 2 kinds of pastures was composed of 3 pairs of 3-acre fields, 1 of each pair being seeded to each of the mixtures and each 3-acre field being subdivided into 6 half-acre paddocks.

Both pastures were grazed rotationally. Five lactating Jersey cows and occasionally a sixth dry cow grazed each 3-acre field using 1 paddock at a time during the grazing period; May 3 to September 14, 1955. The paddocks were mowed after grazing and allowed 28 to 35 days to recover before grazing again. Certain paddocks were harvested for silage or hay when there was an excess of forage for grazing.

Bloat was much more prevalent on the brome containing mixture. The total number of attacks of bloat was 80 with 75 of these being on the pasture containing brome grass and but 5 on the other. This greater incidence was apparently due to the less satisfactory recovery of the brome as the season progressed. Thirty-three attacks occurred between 8:00 a.m. and noon and the remaining 27 between noon and 10:00 p.m.

The cows were on the pastures 131 days but bloat only occurred on 21 of the days (16%). The 21 days were divided among 13 periods of from 1 to 3 days each. The longest period during which no bloating occurred was 20 days except that none occurred during the first 44 days on the pastures. Thus conditions conducive of bloat apparently were only present during occasional periods.

Twenty-one of the 32 cows had attacks of bloat. The ages of the animals ranged between 2 and 10 years and all ages were represented in the group that bloated. The number of times any particular animal bloated ranged from 1 to 10.

Microbiological Observations on Bloat Samples, Norma A. Frank, H. R. Smith, W. D. Pounden, A. Hahn, and A. D. Pratt, Ohio Agricultural Experiment Station

In conjunction with pasture and bloat experiments it was possible to obtain for microbiological examination 8 rumen samples from bloated dairy cows using the stomach method developed at the Ohio Agricultural Experiment Station. Samples also were collected from 2 cows when not bloated on 4 occasions each. The "indicator" method was used to examine the samples.

Estimates of relative concentrations of protozoa were within normal ranges in the samples from both bloated and unbloated animals. The same was true of the two groups of organisms that have been designated as Hay I and Hay II flora. However, as seemd frequently to be true of samples from animals on pasture, the 3 organisms comprising the Hay II group were less numerous than on winter rations. A small difference was noted between the samples from the bloated and unbloated animals. This was the presence of long chains of small organisms in all but one of the 8 samples from the former and in only one of 8 samples from the latter.

Oxidation-reduction potential measurements of 2 samples, one from a bloated animal and the other from a cow on similar feed at the same time, were approximately 100 millivolts higher than those obtained on 2 samples from animals on dry feed.

Group Study at Mississippi State College

The results of the group study concerning microbial activitiy in the rumen carried on at Mississippi State College in the summer of 1954 were discussed by two of the co-workers, R. W. Dougherty of Cornell University, and B. F. Barrentine of Mississippi. The manometric procedures used to measure gas production *in vitro* by rumen samples from bloated and non-bloated animals were described. The rate of rumen fermentation per gram ingesta in bloated animals was found to be higher than in unbloated animals on the same pasture. Saponins and slime production by the microorganisms were considered as possible factors in the formation of the foamy masses. A report recently has been published:

R. E. Hungate, D. W. Fletcher, R. W. Dougherty and B. F. Barrentine. Microbial Activity in the Bovine Rumen: Its Measurement and Relation to Bloat. Applied Microbiology 3 (May 1955) 161-173.

Another procedure that came in for some discussion was the stomach tubing method used in rumen studies at the Ohio Station for a number of years. A description is given in the following reference:

W. D. Pounden. Rumen Sampling -- A Diagnostic Aid. Veterinary Medicine 49 (June 1954) 221.

Effect of Saponin on Froth Formation of Ruminal Contents, Ivan L. Lindahl, U. S. Department of Agriculture

Using a slight modification of the invitro determination for Stable Ingesta Volume Increase as described by Don Jacobson, we have found that alfalfa saponin at the rate of 0.1 g. per 200 ml of ruminal contents increased the formation of froth in all cases. There was a difference in the effect of the saponin on ruminal contents from different cattle. Two commercial steroid type saponins (yucca) which have not produced experimental bloat symptoms were ineffective in stabilization of or formation of froth under the same conditions. The legume saponins are of the triterpenoid type and also appear to have much more pronounced physiological activity than the steroid type saponins.

PHYSIO-PATHOLOGY PANEL

Antibiotics for the Prevention of Bloat in Cattle Grazing Ladino Clover, B. F. Barrentine, C. B. Shawver and L. W. Williams, Mississippi Agricultural Experiment Station

Steers grazed an almost pure stand of Ladino clover for 90 minute periods morning and afternoon. At the end of each grazing period the steers were checked for bloat and put in dry-lot. Under this system a steer could bloat twice daily. Only steers that bloated regularly were used in this study. In 1954 only yearling steers were used and a total of 1575 cases of bloat were recorded. During 1955 two-year-old steers (carried over from 1954) and yearling steers were used and a total of 1643 cases of bloat were observed.

The oral administration of chlorotetracycline, oxtertracycline, bacitracin, streptomycin and penicillin for the prevention of bloat were investigated using the steers and grazing system referred to above. Penicillin was the only antibiotic studied that prevented bloat when a single dose of 300 mg. or less was given. Chlorotetracycline and oxtertracycline both prevented bloat in steers when a dose of 1.0 g. was given but 300 mg. of either did not prevent bloat.

Single doses of 25 mg. of procaine penicillin gave good protection from bloat in yearling steers. Bloat was prevented for $1\frac{1}{2}$ to 3 day periods by a single dose of 50 mg. Older steers weighing about 900 lb. required 50 to 75 mg. of procaine penicillin to prevent them from bloating.

Clover consumption appeared to be slightly higher after penicillin treatment than before. This observation was based upon clipping and feeding the fresh clover to steers before and after penicillin treatment.

Potassium penicillin, in equivalent amounts, was equally as effective as procaine penicillin. The nature of the procaine penicillin carrier and the concentration of the penicillin in the carrier appeared to have no effect. The penicillin had to be given several hours or overnight before it was effective in preventing bloat in steers that were bloating before treatment.

Physical Properties of Paunch Juice Which May Contribute to Bloating, Roy E. Nichols, Wisconsin Agricultural Experiment Station

Definition of the contributing roles of many of the physical as well as chemical processes of paunch digestion are necessary before their relative importance in the production of bloat can be ascertained. The process of excessive frothing often observed in fresh legume and grain bloats is associated with microbial stimulation, bubble retention, increases in viscosity and surface tension of paunch juice samples and extension of these changes into the depths of the paunch. The necessity of caution in assigning primary importance in bloat production to any single change in the plant alone, the animal alone or in microbial action alone is discussed.

The Pharmacology of Some of the Alfalfa Saponins, Ivan L. Lindahl, U. S. Department of Agriculture

The composite isolated alfalfa saponins have pronounced pharmacological actions in addition to their surface tension properties. Experimental data indicate that both properties of the alfalfa saponins could contribute to ruminant bloat, however, more fundamental and clinical data are necessary before the experimental observations can be correlated with the pathogenesis of clinical bloat.

All of the experimental work has been conducted with a composite mixture of alfalfa saponins, which contains six or more individual saponins, and three commercially available saponins. In view of the action of biochemical compounds in general, it is logical to expect that the composite mixture of alfalfa saponins contained fractions that varied considerably in their pharmacological action. The composite isolated alfalfa saponins are extremely active, highly toxic, and have rather pronounced actions on the cardiovascular and nervous systems as well as the digestive system. The degree of the pharmacological actions as well as the toxicity varies with the dosage and the site of administration. Most of the work has been conducted with sheep and all of the following data have been accumulated with that species.

The actions of the saponins on the digestive system is not limited to the rumen alone, but includes the reticulum, esophagus and intestines. Different animals vary in their reaction to the alfalfa saponins, some being very sensitive while others appear to be quite resistant. The intraruminal administration of 10 to 12 grams of the saponin will result in a marked decrease in ruminal motility in some animals while up to 3 times this amount has been given to other animals without any apparent reduction in motility.

The action of saponin on ruminal motility is classified according to Weiss, i.e., a backward moving contraction or major contraction and a forward moving or "eructation" contraction. Saponin appears to have a greater action on the major contraction than on the "eructation" contraction; especially if intraruminal pressure is increased. In some cases the amplitude of the major contraction has been greatly reduced while the eructation contraction has increased in frequency and even in amplitude.

Although a reduction in ruminal motility may be contributory to bloat, evidence indicates that a marked reduction in ruminal motility by itself does not necessarily lead to bloat. Intravenous administration of 1 gram of alfalfa saponin resulted in marked inhibition of ruminal motility and eructation efficiency in 3 out of 4 animals.

The introduction of 1 gram of the saponin into the intestine of an animal, through a duodenal fistula, has resulted in an immediate reduction in the amplitude of the major ruminal contraction and an increase in intestinal motility on several occasions. Although the increase in intestinal motility has been transitory in several cases, the reduction in ruminal motility has been quite prolonged. Although some of the action of the saponins may be due to a direct action on the ruminal musculature, all of the observations cannot be explained on this basis.

The intraruminal administration of moderate amounts of the saponin or intravenous administration usually results in an increase in the respiratory rate and then in an irregular respiratory pattern. In all experiments in which the saponin has been slowly injected intravenously until the animal collapsed, respiratory failure has proceeded cardiac failure. Data revealed that there was little or no change in oxygen consumption following the intravenous injection of the saponin, although there was a marked alteration in the respiratory rate and rhythm, indicating that the seponin may have a direct action on the respiratory centers.

The action of the saponin on the cardio-vascular system is rather complex. Although saponins are well known for their ability to hemolyze blood, we have found no definite correlation between blood hemolysis and other physiological actions. Intravenous injections of approximately 1 gram of the saponin may or may not result in detectable blood hemolysis, but does result in marked changes in the blood cell counts. A marked rise in the red blood cell count and marked decrease in the white cell count has followed intravenous injection of the saponin. Intravenous injection of the saponin appears to result in a rapid and marked drop in blood pressure immediately following the dosage. With small doses this reaction appears to be transitory in nature, with the blood pressure returning to normal within a short period. Subsequent doses also result in the same reaction, with the pressure returning to near normal until shortly before death. The most pronounced reaction of the saponin on cardiac action appears to be a decrease in the heart rate following intravenous injection.

The toxic levels of the composite alfalfa saponin appear to be approximately 50 to 60 grams when given orally or 1 gram when given intravenously; however, death has not been rapid at these levels unless the animals were displaying marked bloat symptoms, i.e., 40 to 50 mm. Hg pressure. If the animals collapsed with marked bloat symptoms, the usual symptoms were excessive salivation, frequent urination and defecation and extreme restlessness just before collapse. In the cases where the animals displayed slight to moderate or no bloat symptoms, death did not occur until 2 to 7 days following the saponin administration. These animals did not appear to be in distress until a few hours preceding death when the customary symptoms were rasping and labored respiration.

Only three animals were given 100 grams of saponin in intraruminal doses. The first two animals displayed marked bloat symptoms and died within two hours, while the third animal displayed only moderate bloat symptoms and did not die until 27 hours after the dosing. The first two animals displayed bloat distress symptoms preceding death while the third animal displayed symptoms suggestive of central nervous system disturbances, such as incoordination and muscular spasms, for three to four hours preceding death.

The typical findings on gross examination of the animals that died as a result of saponin administration have been congestion of lung tissue, inflamation, hemorrhage, and congestion of the small intestine and hyperemia of the walls of the abomasum, regardless of the site of the saponin administration. Heart abnormalities were found in less than half of the gross examinations. The rumen, reticulum and omasum were found to be essentially normal in animals that did not display marked bloat symptoms, but hemorrhage of the walls of the rumen was found in all cases where the animals collapsed with marked bloat symptoms. The spleen was found to be engorged or hemorrhagic in most of the cases where the animals collapsed with marked bloat symptoms.

Although gross pathology of the kidneys and liver was not as apparent and typical as the symptoms listed, histological examination revealed consistent and severe damage to these organs. In fact the damage to these organs appeared to be severe enough to have resulted in the eventual death of the animals.

In comparing the action of the alfalfa saponins with other plants saponins, it should be pointed out that the alfalfa saponins have a triterpenoid nucleus while many of the other plant saponins have a steriod nucleus. Two saponin preparations from the yucca plant (steriod type) have not produced bloat symptoms or affected ruminal motility and have not resulted in the death of any animals when given under the same conditions as the alfalfa saponins. Another triterpenoid saponin (Quillai) has been fully as active as the alfalfa saponin and appears to be more toxic.

The Physiological Response to Ammonium Carbamate, L. C. Payne, Iowa State College

The level to which urea can be added as a protein nitrogen replacement in ruminant feeding is determined by the toxicity of urea itself, some of its end products or by-products of digestion. Numerous reports have been published which state that the toxicity of urea is due to the rapid liberation of ammonia in the rumen and the subsequent absorption of this toxic substance. Clark and others (1951) suggested the cause of death may be due to some toxic end product, or products, of rumen fermentation. Repp, et al. (1955) reported on the oral administration of non-protein nitrogen compounds and the blood ammonia and urea levels in lambs.

Kaishio et al. (1951) from Japan reported the possibility of ammonium carbamate formation from urea degradation in the rumen, with the toxicity of urea being dependent upon this compound. Hale and King (1955) made a preliminary report on the effect of ammonium carbamate administration to lambs. They concluded that urea toxicity in the ruminant is not due to ammonia but to the liberation and absorption of ammonium carbamate.

A reivew of literature failed to uncover much information concerning ammonium carbamate, and nothing concerning its physiological activity. Hence this study was initiated.

This abstract will present only the pertinent results of this study to date. Unless otherwise stated, dogs were used as the experimental animals.

1) Anesthesia with pentobarbital sodium had little effect on the carbon dioxide carrying capacity and the pH of blood within the first hour and one-half.

2) The administration intravenously of 50 mg/kilogram of sodium bicarbonate raised the CO_2 combining capacity 8-10 volumes per cent immediately after injection (63 vol.% to 73 vol.%). The pH remained unchanged.

3) The administration intravenously of ammonium carbamate raised the CO_2 combining capacity immediately to 76 vol.%; however within 10 minutes, the level returned to normal. Ammonium carbamate inhibits respiratory movements, hence the collection of carbon dioxide in the blood assists this return to normal.

4) The toxic level of ammonium carbamate injected intravenously appears to be from 90 mg/kilogram to 100 + mg/kilogram, death resulting from complete inhibition of the respiratory apparatus. The animal can be maintained at this level indefinitely if administration of artificial respiration is applied.

Blood pressure and respiration tracings were taken on approximately 18 dogs following the administration of ammonium hydroxide, ammonium chloride, ammonium acetate and ammonium carbamate. The dosage levels were determined on the ammonium equivalents in milligrams per kilogram of body weight.

The results of these studies are as follows:

1) All of the above compounds stimulate respiration when given at levels below 20 mg. NH_3/kilogram. Respiration is inhibited when the level is from 20 mg/kilogram to 35 mg/kilogram. Respiration is stopped and death results when the level exceeds 35 mg/kilogram.

2) All of the above compounds have a marked cardiac inhibitory effect. Blood pressure is maintained within the normal range, however the heart shows extreme parasympathetic stimulatory effects. These effects can be removed by double ligation and sectioning of the vagi nerves, or the injection of atropine sulfate.

3) The upper levels of ammonia administration cause marked stimulation of the intestinal tract, defecation and urination.

4) The respiratory inhibition due to these ammonium compounds responds to 'Metrazol' stimulation but not to 'Coramine' administration.

The injection of the above ammonium compounds into normal dogs produced the same symptoms as those seen in acute poisoning with urea. Severe muscular spasms, dyspnea, excessive salivation, defecation, urination, and ultimate recovery or death, depending upon the level given.

Injections of ammonium hydroxide, intravenously, into lambs (76-90#) at the same dosage that Clark, et al. used, did not cause any of the symptoms seen in urea poisoning.

The intravenous injections of ethyl carbamate and methionine carbamate produced little or no visible effects on the animal.

An Open Discussion on Evidence for and Against HCN, pH, Enzymes or Hormones as Factors Involved in Bloat, W. E. Thomas, North Carolina State College

In summary there is very little evidence that the hydrocyanic acid content of forages has any connection with the bloat problem. Hydrogen ion concentration probably does not have any direct connection as a cause of bloat unless some unknown process depends on a very narrow pH range for healthy activity. Very little is known about enzyme processes in the rumen but fundamental studies on this phase are in order even if it turns out that no relationship to bloat exists. The hormone appraoch to the bloat problem is wide open. There is nothing in the literature in my opinion to encourage or discourage this as a handle for studying the cause of bloat.

Studies of Eructation in Decerebrate Sheep, A Preliminary Report, R. W. Dougherty, Cornell University

The use of an elderly method (decerebration) that is still popular and productive in Britain in studying the autochthonous reflexes and the parts of the nervous system involved in certain motor or secretory events has been used to great advantage in studying eructation in sheep. The physiological experiments were preceded by anatomical orientation with dissected specimens. These findings will be reported later when formal publication of a completed segment of the work is accomplished.

Sheep were anesthetized with ether, the carotid arteries located, the top of the skull was removed, hemorrhage controlled as effectively as possible by temporarily clamping the carotids and using hemostatic agents. "High" decerebration was performed, care being taken not to injure the thalamencephalon or other parts of the brain stem. Decerebration was performed as rapidly as possible. After completion of the operation anesthesia was discontinued, the carotid artery clamps were removed, the skin sutured over the skull and the table was tipped so that the animal was supported at approximately 45° from a true upright position. If the animal did not have a permanent rumen cannula fistula, a cannula was inserted into the rumen in the left paralumbar fossa using the regular operative technique employed in this laboratory.

The cervical esophagus was then carefully exposed. Artificial respiration was started. The first 8 or 9 ribs were removed and the left lung was removed. This exposed the esophagus from the cephalic end to the hiatus esophagus.

By inflating the ruminoreticular pouch eructation could be induced. Electrical stimulation of nerves supplying the esophagus during its dilation phase brought out the limits of the motor events more vividly.

The motor supply to the esophagus and its sphincters has been studied by electrical stimulation and pharmacodynamically.

Cine recordings of the preliminary work were shown and their implications discussed.

AGRONOMIC PANEL

The Aftermath Production of Three Pasture Grasses Following Clipping to Control Flowering, E. C. Spurrier and J. A. Mackobs, University of Illinois

Bloat in ruminants is most generally associated with legume pastures. Where animals are allowed to graze pastures of mixtures of about equal proportions of grasses and legumes or pure stands of grass, bloat is minimized. Oftimes unfavorable climatic conditions and disease prevent adequate forage seedling establishment or permit the loss of one or the other components of a grass-legume mixture. Grass management becomes especially important when a legume is not present in a pasture mixture. The legume may be left out of the seeding mixture because of the danger of bloat or it may have disappeared because of disease or environmental factors.

The forage quality of grasses is generally influenced by the stage of maturity at which time they are harvested. A high proportion of seed stalks present in a sward reduces the forage quality. The proportion of seed stalks present in the harvested forage increases as the development of the grass approaches maturity. The seed stalks grow out rapidly early in the season. Following the first cutting after they emerge, no more seed stalks are produced; the balance of the growth during the season is leafy. Various clipping schedules were imposed upon pure stands of orchard grass, smooth brome grass, and tall fescue to determine how early the first cutting can be made and still eliminate flowering in the subsequent growth. The ability of the grasses to produce forage under the various clipping schedules was measured in terms of yields of late summer aftermath and total seasonal yields of forage. Forty pounds of nitrogen were applied on the grasses three times during the season, early in March, immediately after removal of the first harvest in the spring, and on August 1, making a total of 120 pounds of nitrogen applied.

The first cuttings were made at four stages of maturity: vegetative, boot stage, early head, and full head. Forage yields of orchard grass were less than smooth brome or tall fescue for the first spring harvests regardless of the stage of maturity at which they were clipped. As expected, forage yields of all three grasses increased as the stage of maturity advanced.

After the first harvest, the recovery growth was subjected to various clipping frequencies until August 1 at which time the entire experimental area was clipped and the forage removed. During this period, recovery yields of orchard grass were considerably higher than either scmooth brome or tall fescue. The smooth brome recovered very slowly after the first clipping. For all three grasses, as the clipping frequency increased, forage production decreased. In every case orchard grass produced more forage than the other grasses. The proportion of seed heads present in the sward of the regrowth material was progressively less for the plots which had the first harvest forage removed in the spring at the more advanced stages of maturity. When the first spring harvest was made at the vegetative stage, the proportions of seed heads produced in the recovery sward were about 20, 87, and 98 percent respectively for orchard grass, smooth brcme, and tall fescue. At the boot stage, the proportions of seed heads produced in the sward were about 5, 7, and 30 percent respectively for orchard grass, smooth brcme, and fescue. There were no seed heads produced in the recovery sward of the grasses cut at the early head or the full head stage of maturity.

The residual effects of the slipping treatments were effected by allowing the grasses to recover and grow unclipped frcm August 1 to September 15. At this time the entire experimental area was again clipped and the forage removed. The yields of aftermath produced during the period from August 1 until September 15 indicated that the stage of maturity at which time the first harvest was made in the spring had little effect on the production of late summer pasturage. Yields of aftermath for orchard grass were higher than for fescue with smooth brome being the lowest during this period. The clipping frequency prior to this period had little effect on yields of aftermath. It is significant that orchard grass produced more aftermath after the more frequent clipping treatment than either smooth brome or fescue. With regards to total seasonal yields, when the forage was allowed to mature to early head or late head stage before the first spring harvest was made, higher total yields of forage resulted. Orchard grass produced more total forage than tall fescue with smooth brome being the lowest for the season. The yields at Urbana were 4.93, 4.51, and 4.13 tons of 12% hay respectively. Again as clipping frequency increased, forage production decreased. Tall fescue produced more total forage under the less frequently clipped treatments and orchard grass produced more total forage on the more frequently clipped series of treatments. Orchard grass produced 47% and 29% more leafy forage than brome grass and frescue respectively. The leafy forage produced from the grasses that were first cut in the spring at the vegetative stage of maturity was about 38 percent more than that produced by the grasses that were first cut in the spring at the full head stage.

Influence of Nitrogen and Phosphate Fertilizers Upon the Yield and Chemical Composition of Smooth Bromegrass, Kling L. Anderson, Kansas Agricultural Experiment Station

Although alfalfa commonly is sown with such cool season pasture grasses as smooth brome in Kansas, there is much prejudice against it and other legumes because of the bloat hazard. Some farmers have gone so far as to eradicate the legume with 2, 4-D, and many plant grass alone, expecting to maintain forage yields with commercial fertilizers.

Liberal use of nitrogen fertilizer (and others as needed) does maintain yields of both forage and seed. During seasons of favorable moisture, it is not uncommon to obtain 5-fold increase in forage yields from 100 pounds of nitrogen per acre applied to "sod bound" smooth brome. Forage yield increases tend to be proportional to the amount of nitrogen applied up to 100 pounds of the element per acre, but level off beyond that amount. Protein percentage (in terms of total nitrogen) climbs strikingly up to about the 200 pound rate and carotene percentage follows that of protein.

Increasing rates of nitrogen application cause a marked increase in ammonium ion in the forage. Amides increase rapidly with heavy fertilization during the early stages of growth, but decreases as the forage matures. It is suggested that the plants synthesize amides as a means of storing the excessive amount of ammonium nitrogen absorbed.

The nitrate content of forage is increased markedly by heavy applications of ammonium nitrate fertilizer, but only at extremely heavy applications does it reach potentially dangerous levels, and then only briefly at early stages of growth.

Riboflavin content is also increased by moderate applications of nitrogen, while greater applications cause but little further increase.

Effect of annual application of N and P_2O_5 fertilizer on dry matter yield of smooth brome. Five year average (1947-1951) of two spring and two fall dates of application.

N Per Acre (lbs)	Dry matter per acre: Without P_2O_5 (lbs)	Dry matter per acre: With 80# P_2O_5 annually (lbs)	Average
200	4813	4582	4798
140	4989	4736	4863
100	4714	4913	4814
60	4523	4431	4477
20	3027	3918	3473
0	2619	2679	2649

From these data it may be concluded that the use of commercial fertilizers will maintain satisfactory forage production in smooth brome. Data are not available to compare costs of fertilization with the use of legumes to supply nitrogen.

Fertilizer and Irrigation Effects on the Ratio of Clover to Bermuda Grass, O. E. Sell, Georgia Experiment Station

The clover-bloat problem is much more serious in some years and also in some seasons of the year than in others. This is generally thought to be related to the percentage of clover in the sward. Over an eight year period there have been predominantly clover years, and within years there have been seasons when clovers tended to be dominant. It is primarily during these clover dominant periods that effective treatments for reducing the proportion of clovers should be sought. Certain carry-over or long time effects of treatments may play an important roll in determining the clover-grass ratio.

In four out of eight years clovers constituted over 50% of the total annual forage yield; in three years clovers constituted 10% or less of the forage, with mineral fertilizer program (lime, P, K.). The use of 64 lbs. and 128 lbs. of N reduced the percentage of clovers to 27.4 and 14.3 respectively, averaging these four high clover years. The addition of P or P and K with 64 lbs. N increased the percentage of clover into the 40-60% range. With 128 lbs. N applied annually the addition of P or P and K raised the annual clover percentage into the 20's or low 30's.

The addition of supplementary irrigation encouraged clovers to such an extent that no P or K could be used if the percentage of clovers was to be kept below 40%. Either 64 or 128 lbs. N per acre annually used without P or K fertilization kept clovers below 40% of the total year's forage yield, with irrigation.

Upwards of 60% of the total year's clover production is usually obtained in the cool spring April thru June season. Since Bermuda is a warm season forage plant N fertilization for this grass is not started until mid-May. Such late spring and summer use of N topdressings can cause soil depletion of P, K and other minerals in one year which can then reduce the clover yield and clover-grass ration in following years. Sound long-time fertility management of clover-grass pastures would dictate against such unbalanced fertilizer practice. A solution to this predominantly clover forage in early spring with its high bloat potential, would be to utilize it for silage, or to find a cool-weather grass to grow in association. Rescue grass has some potentialities for this purpose.

When adequate rainfall and other conditions tend to encourage clover growth during the warm summer months, at a time that Bermuda grass growth is also favored, the use of N fertilizer definitely has changed the proportion of clover to grass from one that has bloat potentialities to one unlikely to cause bloat. In June, 1943 for example, clovers constituted 50% of the forage with mineral fertilization while the use of 32 pounds of N reduced the clover to 30% of the forage. Where supplementary irrigation had previously been practiced, it required 64 pounds of N per acre and in conjunction with unbalanced mineral fertilization to reduce the clover to less than 30% of the total forage.

Incidence of Bloat in Iowa Pasture Experiments, J. M. Scholl, Iowa Agricultural Experiment Station

For the 10 year period 1946-1955, inclusive, a total of 1030 Hereford steers were pastured and fed out in pasture utilization studies in Western Iowa. Eight hundred and thirty-six of these cattle had brome-alfalfa pasture or soilage for the pasture season. The rest had hay and corn in the conventional drylot management as controls for evaluating pasture.

Death losses during this period were 14 from all causes. Seven of these losses were diagnosed as bloat. Losses from bloat were under 1% for these cattle. These deaths occurred in June and July only.

The largest number to bloat at one time was in 1954 when three animals died the first week of June. One was getting pasture only, one had fresh clippings only and one had clippings and corn. After these cases there was no more trouble with cattle apparently eating the same feeds.

Feeding fresh cut forage has not prevented bloat losses in these studies or in farmers' feed lots. Six deaths from bloating in a 60 cow herd were reported by a farmer in N.C. Iowa about the first of June 1954. He fed fresh cut forage entirely.

Irrigated Pasture Studies with Beef Cattle, R. W. VanKeuren and W. W. Heinemann, Washington Agricultural Experiment Station

Four grass-legume mixtures and two pure grass stands are being compared as pasture for yearling steers at the Irrigation Experiment Station, Prosser, Washington.

Pure stands of tall fescue and of orchardgrass are being used. Alfalfa with each of the two grasses and Ladino clover with each of the grasses make up the four mixtures. The pastures were established in 1953 and two years of grazing with yearling Hereford steers have been completed.

Annual applications of 200 pounds of available nitrogen per acre were applied to the pure grass pastures. This amount is applied in three equal applications--mid-March, mid-June, and late July. The grass-legume pastures received a total of 100 pounds of available nitrogen annually in three applications at the same intervals. Previous trials have shown that this amount of nitrogen can be profitably used on grass-legume pastures and yet maintain a satisfactory percentage of legume. A high level of available phosphate is maintained. Furrow irrigation is used.

The grass-legume mixtures have consistently produced more beef per acre than the pure grass pastures. In 1954 the grass-legume mixtures produced an average of 1,080 pounds of beef per acre and the pure grass pastures 816 pounds.

Sixteen cases of bloat were observed in the 1954 grazing season, involving twelve animals, with five death losses. All occurred on grass-legume pastures. Despite the loss from bloat on the grass-legume pastures, the average pounds of beef produced per acre was higher on these pastures even after the total weight (at death) of the five animals was deducted from the pounds of beef produced on the grass-legume mixtures. The net amount of beef produced after deducting the death losses was 850 pounds. In addition, the cattle that grazed the grass-legume pastures had a higher values--from $1.00 to $1.50 per hundred--at the end of the grazing season.

Only one case of bloat was treated in 1955 and no death losses occurred. The only difference in procedure for 1955 over 1954 was the feeding of wheat straw free choice in bunks in areas adjoining the pastures. The average daily consumption of straw was about one pound per steer.

Toxic Concentrates from Ladino Clover, R. A. Shaw and H. D. Jackson, Purdue University

Concentrates from various extracts of ladino clover, a bloat-producing forage, were tested for this physiological effects. Dried ladino clover was extracted with benzene and the extract filtered. The benzene residue was re-extracted with 50% ethanol and the extract concentrated and fractionated with butanol to remove saponins. The low-saponin aqueous concentrate from this fractionation was assayed. The saponin-rich butanol phase and the benzene extract were each converted into an aqueous solution before assay. The ladino clover concentrates were assayed for their effect on oxygen consumption and on contraction of smooth muscle from the rat. The low-saponin aqueous concentrate gave the greatest inhibition of oxygen consumption and caused paralysis of the muscle. Sheep red cells were also treated with the concentrates; red cell cholinesterase activity, which reflects the animal's capacity for nerve transmission, was reduced to some degree by all concentrates. When sheep were injected I.V. with the ladino clover concentrates the low-saponin aqueous fraction caused the animals to fall and produced miosis and severe tetany. The benzene concentrate and the saponin-rich butanol concentrate caused milder symptoms. Data suggest that ladino clover contains substances, other than saponin, which are toxic to sheep if injected intravenously. At least part of this inhibition appears due to anticholinesterase activity. Constituents from the active concentrates are possibly associated with bloat on ladino clover pasture.

RUMEN PHYSIOLOGY PANEL

Use of Chronic Vagal Electrode Preparations in Studies of Factors Affecting Motor Functions of the Ruminant Stomach, H. E. Dziuk, C.E. Stevens, and A. F. Sellers, University of Minnesota

It had been our hope for some time to explore the possibility of developing a chronic preparation, in bovine subjects, which could be used repeatedly in the unanesthetized state, for studies on several aspects of ruminant stomach function.

An initial study in this direction was begun, using calves. Seventeen dairy-type male calves were subject to thoracotomy for the purpose of applying silver electrodes to the dorsal and ventral vagal trunks, posterior to the heart. Eleven of the seventeen animals made complete recoveries and were used.[1]

One group of four calves allowed access to roughage from birth showed, (a) greater spontaneous motility, and (b) greater stimulated (vagus) motility, than a second group of five calves milk-fed from birth. Two calves, started on milk, then switched to roughage, required about 60 days for attainment of "roughage-fed" type motility.

At the time of slaughter (approximately 90 days of age), intact axis cylinders in nerve sections, and the lack of excessive connective tissue or other inflammatory change at the point of electrode application, were taken as evidence that electrode placement did not interfere markedly with normal nerve structure. Further, no definite or regular changes were observed in sections of the vagal nuclei.

Three adult Holstein females were surgically prepared with rumen fistulae and dorsal thoracic vagus electrodes.[2] In these animals, studies were carried out with reference to the development of quantitative recording procedures, using a modification of the method described by Brody and Quigley.[3] It was found that, with the method as finally used, in no case was a tube-tip recording pressure change in compartments other than its own, with a few easily distinguished exceptions.[2] Further, it was determined that eructations, swallows, and regurgitations were easily distinguished from each other on the tracing.

The results of stimulation over a three to six month period post-operatively appeared to indicate that, (a) "moderate" electrical stimuli applied to the dorsal vagus were associated with an increased rumen contraction rate and increased eructation rate; (b) that "strong" electrical stimuli applied to the dorsal vagus were associated with interruption of normal rumen and reticulum cycles and with cardiospasm; and (c) that with submersion of the cardia six to eight inches with water, "moderate" vagal stimulation was still effective in increasing the rate of eructation of gas.

Experiments currently under way include those on two adult animals successfully surgically prepared with "double" electrodes (one ahead of the other, separated by about four or five centimeters) on the dorsal thoracic vagus. These electrodes were also each supplied with an extra polythene tube. Four percent procaine hydrochloride solution injected into either electrode was followed by bloating to approximately 40 mm Hg rumen pressure in a ten to fifteen minute period, with noticeable decreases in amplitude and rate of rumen contractions, and in eructation rate.

Initial indications in these two animals are that procaine applied to the anterior electrode is followed by bloating (as above) and inability further to elicit eructation or rumen responses using vagal stimulation via the posterior electrode.

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Cinefluorographic Studies of Eructation in Sheep, R. W. Dougherty, Cornell University

During the past two years fifty cinefluorographic films have been made of sheep and the structure involved in eructation. Young western sheep, weighing between 40 and 60 pounds, were used in the experiments. The cinefluorographic work was done by members of the Department of Radiology of the University of Rochester School of Medicine and Dentistry.

Exposures were made at approximately 125 kilovolts with milliamperage values ranging frm 40 to 80 and a time limit of 18 to 25 seconds using a camera speed of 15 frames per second.

In general much of the time was devoted to studies of esophageal activity and motor events in the anterior part of the rumen and in the reticulum.

By insufflating the rumen and reticulum eructation was stimulated. Insufflation was accomplished through permanent rumen-cannula fistulas.

The main events observed during eructation were as follows:

a) Two contractions of the reticulum.
b) Contraction and raising of the ruminoreticular fold.
c) General ruminal tonus or contraction forcing gas forward and downward into the relaxed and relatively empty reticulum.
d) Increased eructation activity (contraction and dilation of the esophagus).
e) Relaxation of the two caudal esophageal sphincters.
f) Gaseous distention of the esophagus.
g) Continued closure of the cranial esophageal sphincter retaining the gas in the esophagus until the cardial and diaphragmatic sphincters closed.
h) Closure of the glottis causing a transient rise in intrapleural pressure which aided the esophageal musculature in rapidly clearing the esophagus of gas. This occurred through the relaxed cranial esophageal sphincter.

This, in brief, outlines the main motor events of eructation visible under the conditions of the experiments.

Eructation Studies in Cattle, H. W. Colvin, P. T. Cupps and H. H. Cole, University of California

Rumen motility can be determined by (1) the use of partially inflated balloons placed in the various sacs of the rumen and then connected to some recording system; (2) X-rays; (3) visual inspection; (4) palpation; and (5) measuring the pressure changes occurring in the rumen by inserting a cannual in the rumen and connecting it with a recording system.

When using (5) above, large and small deflections are recorded. The large deflections are thought to be concerned with the contraction of the dorsal sac while the small contractions are associated with simultaneous activity of the ventral, posterior dorsal blind and posterior ventral blind sacs. The larger moves material, either gaseous, solid or liquid, backward, and the smaller moves it forward. Eructation usually occurs on the peak of the small deflection although it has been observed on large ones as well.

The large and small deflections seem to occur in definite ratios (large contractions to small contractions) of 1:1, 2:1, 3:1, 4:1, 1:2, or 2:2. These ratios vary with changes in intra-rumen pressure, i.e., when the intra-rumen pressure increases, there is a rise in frequency of the 1:1 ratios and thus an increased rate of eructation. This illustrates a reflex method of controlling eructation.

A method has been devised whereby it is possible to determine the frequency as well as the magnitude of each eructation. The technique involves exposure and transection of the trachea followed by the suturing of the ends of the trachea to the exterior. The belched gas is conducted to apirometer through a system of hoses which are connected to an air-tight mask over the muzzle and a plastic cannula inserted in the cephalic end of the sectioned trachea. From such an arrangement, it would be expected that the gas would pass from the mask, however, it was found that the major quantity actually went through the cephalic tracheal cannula. If this cannula became clogged for any reason, the animal bloated regardless of the diet.

Data gathered by using the method just described, indicates that the average amount of gas per belch was greater when the animals were fed alfalfa tops than when the diet consisted of a combination of alfalfa tops and oat hay or oat hay alone. This can be partially explained by the fact that the frequency of eructation was greater on the alfalfa top-oat hay and oat hay diet. In effect, the gas was belched as rapidly as it was evolved in the rumen. However, when alfalfa tops alone were fed, belching frequency was at a very low level and the animals bloated. It is believed that the ingestion of alfalfa tops contributes to the formation of a stable frothy condition of the rumen ingesta and that this froth is important in the blocking of the cardiac orifice and thus eructation. When this occurs, any gas which may be present in the free form accumulates in a pocket in the dorsal sac and cannot be belched away. After a time, however, the foamy condition is sufficiently dispersed to allow the escape of the free gas up the esophagus at the time of eructation. Once eructation begins, the gas is expelled very rapidly as evidenced by the magnitude of the belches (4 to 6 liters per belch as compared to the usual of 0.8 to 1.5 liters per belch in non-bloated animal). Therefore, the high average amount of gas per belch observed when the animals were fed alfalfa tops is a result of two factors, (1) a decreased total number of belches because of an incomplete eructation mechanism during the bloated condition and (2) an increased volume of gas per belch when complete eructation finally did occur.

The frequency of the small or "eructation" contractions was greatly increased on the alfalfa top diet as a result of the increase in intra-rumen pressure. Theoretically, the number of eructations should have increased in such a situation and probably would have if froth would not have been present. On the oat hay diet, the number of eructations almost equaled the number of small or "eructation" contractions.

That froth appears to be an important factor preventing eructation when animals are being fed young succulent legumes, is suggested by trials in which froth formation was prevented by the intra-rumen administration of 200 ml. of "Wesson" oil. Intra-rumen administration of the oil in a bloated cow relieved the condition within 10-15 minutes. When no oil was used, bloat was observed.

Research on Bloat at the Grassland Station, Palmerston, North New Zealand,
W. E. Petersen, University of Minnesota

Because of the extensive use of luxuriant pastures consisting of clovers and rye grass bloat is a serious problem to the New Zealanders. At the Grasslands Station a series of experiments have been conducted, the results of which have suggested a solution to the most dominant type of bloat occuring in that country.

First they have ascertained that the dominant form of bloat is caused by the incorporation of the gases in their ingesta without any free gas. As a matter of fact, experiments conducted by the New Zealand workers show that, even with marked distension of the rumen, any free gas is eructated. The most common bloat in New Zealand, therefore, appears to differ from the most common type in the midwest. In this there appears to be in most cases free gas, with the natural assumption that something in the forage interfers with the eructation syndrome and that in animals so bloated removal of the gas by means of the trocar and cannula technique recovery is effected. In the frothy type of New Zealand bloat the trocar and cannula is of no avail unless the cannula is sufficiently large to permit a free escape of the frothy ingesta.

Although bloat is poratic throughout the year the greatest incidences occur in the spring and the fall. Under conditions where clover growth is dominant to that of grass in the mixture and in which the growth conditions are optimum, in other words, rapidly growing clover.

Experiments have shown that the addition of large quantities of dry forage does not prevent bloating under those conditions. Also when the plants produce bloat separation of the leaves and the stems have shown that either portion of the plant is capable of producing bloat.

In the bloated animal relief from the condition is afforded by a drench of a quart of 10 percent oil emulsion. A number of different oils including mineral oil have been tried and no essential difference in their effectiveness has been noted. Most of their experimental work has been done by the use of the peanut oil emulsion, since this oil happened to be the most available. Cream, as a matter of fact, has proven to be equally efficient.

One of the most significant practical developments in New Zealand was that of spraying the bloat producing pastures with a 10 percent emulsion of peanut oil, so as to give a calculated daily intake of about 3 ounces of the peanut oil per animal. This rate of spraying applies to the New Zealand system of a daily change to a fresh pasture in which the grazing management is so adjusted that the cows will adequately graze down the pasture allotted each day.

The research workers at the Grassland Station have found that even with moderate rain, spraying can be done up to three days in advance of grazing, without losing the protective power of the spray.

The writer was fortunate to visit this experiment station on the day when a pasture bloated every animal grazed thereon. While a portion of the same pasture that was sprayed not a single animal bloated.

Following is the formula that was used for the multiplied peanut oil. Peanut oil-10 parts, water-20 parts, Lissapol U-1½ parts of the 10 percent solution.

Lissapol U is a detergent which is used as the emulsifying agent. Apparently other harmless detergents will be as effective.

The general story under the title "Bloat Can Now Be Controlled," by P. D. Sears and C. S. W. Reid, appeared in the New Zealand Dairy Exporter, September 1955.

ANIMAL MANAGEMENT PANEL

Prevention and Management of Bloat on Irrigated Pastures, H. W. Colvin, Jr. University of California

Legume pastures offer the greatest potential source of nutrients for ruminants. Indifferent use of such pastures especially in the immature succulent state, however, can lead to disastrous losses from bloat. It is highly important, therefore, to determine how best to utilize productive legume pastures.

Mixture of Grasses with Legumes - A rule of thumb is that protection from bloat is afforded if a pasture mixture consists of at least 50% grasses with the legumes. This recommendation is effective only if the constituents of the pasture are consumed in approximately this ratio. Proper pasture control, such as occasional clipping, is essential in such a program.

Allowing Legumes to Mature Before Pasturing - Results from work conducted in New Zealand, South Africa, and this country indicate that, in general, the incidence of bloat can be reduced by allowing legumes to reach a relatively mature stage before pasturing.

Feeding of Hay - Well controlled experiments have shown that the overnight feeding of high quality Sudan grass or oat hay, in amounts exceeding 10 lbs. per animal, is completely effective in preventing bloat the ensuing day when animals are turned out to graze on bloat-provoking pastures. Other grass hays may be equally effective, but controlled experiments on them are lacking.

Alternating Sudan and Alfalfa Pastures - In trials with lactating dairy cows, it was found that bloat was prevented when the animals grazed immature alfalfa pasture if they were given access to Sudan grass pasture during the night before.

Soiling in Bloat Prevention - While it is true that soiling reduces the incidence of bloat caused by immature stands of legumes, other preventive procedures, such as the feeding of oat or Sudan hay, are necessary adjuncts to provide complete prevention.

Use of Anti-Foaming Agents - Evidence from several laboratories indicates that excessive foaming is a common characteristic when animals are pastured on legumes. Some workers claim complete success in bloat prevention and cure by the use of silicones, turpentine, and oils while others have had only limited success. The agents used have the common property of being able to disperse foam or froth.

Other Preventive Procedures - Other procedures have been suggested for preventing bloat on legumes: Pasturing the legumes when free of dew, restricting the period and area the animals are allowed to graze at any one time, avoid pasturing frosted legumes, etc. None of the procedures have proved to be practical in bloat prevention.

Prevention and Management of Chronic Bloat, J. T. Blake, Iowa State College

Inasmuch as bloat terminology is not uniform due to the various manifestations of this syndrome, a definition of chronic bloat as used herein may be in order. In this discussion chronic bloat will be considered to be the type which occurs on dry rations containing a substantial amount of forage in contrast to pasture type bloat and to heavy concentrate (feed lot) type bloat. The condition may appear insidiously and continue over a prolonged period of time with only gradual bloat pathogenesis resulting. The term "chronic" indicates a long morbidity period and recurrence of clinical symptoms. Cases may range from mild to severe and may terminate in death. Usually, however, morbidity is high and mortality is low.

Cases of chronic bloat have been observed which appear similar clinically but differ greatly in other respects. Three distinctly different types have been observed. One is a gas pocket type where rumen fluid drawn at the time of bloat is not foamy and usually does not differ appreciably from rumen fluid drawn when the individual is not bloated. Also, the rumen fluid does not differ consistently from samples taken from non-bloating animals on a similar diet. Criteria used were surface tension, viscosity, specific gravity, pH and appearance. Bloated individuals can be relieved by means of a stomach tube, and the barrel circumference often decreases 20 to 30%. The escaping gases are highly combustible. This type of chronic bloat is observed frequently in Iowa cattle.

A second type of chronic bloat has been observed wherein the ingesta is a foamy mass similar to ingesta in feed lot type bloat. When compared to ingesta from individuals with the gas pocket type of chronic bloat, the rumen fluid from these bloated animals generally shows the following: higher viscosity; lower specific gravity and pH; and similar surface tension. This comparison between rumen fluid samples, drawn from animals with the two types of bloat, remains relatively constant irrespective of the degree of bloat at the time of sampling. Little gas can be eliminated via a stomach tube in this frothy type of bloat.

A third type of chronic bloat has occurred in several young dairy calves. In these cases it is suspected that the gas originates in the intestine and migrates into the rumen, thus resulting in secondary bloat. Such cases have occurred only on certain feeding regimes and have been corrected by altering the ration.

Most cases of chronic bloat have been quite severe. In some instances abdominal distention has been so great that the lumbar vertebrae outline is nearly hidden. Apparenly such extreme malformation can occur with little malaise because a partial loss of abdominal muscle tonus has occurred due to constant and prolonged distention. In one bloated dwarf animal the barrel circumference was 91 inches initially and decreased to 73 inches after the individual had spontaneously eructated 81 times in 78 minutes. Eructation did not occur, however, as long as the animal was standing. It is interesting to note that both rumination and active rumen motility occurred during the 78-minute period.

Several prophylactic measures have been employed experimentally on chronic bloating animals. A sudden change in ration composition only temporarily decreased bloat incidence and severity. Likewise a transfer of animals to a new location and feed source only temporarily decreased bloat incidence and severity. Likewise a transfer of animals to a new location and feed source only temporarily decreased bloat. In no case has a change in management procedures been effective in permanently decreasing either incidence or severity of chronic bloat, nor has the use of scabrous feed made any difference.

Representative products of all the present popular pharmaceutical agents have been used at prophylactic and/or therapeutic levels. Such agents include antiferments, antibiotics, surfactants, antifrothing agents, hydrogen-ion alterants and others. Although in some cases a temporary decrease in bloat has occurred following the use of a particular agent, the effect could not be clearly attributed to the medicament. This is true both in gas pocket and in frothy type chronic bloat.

A surgical approach has been employed by some practicing veterinarians. A short length of stomach tube has been surgically fitted and secured so as to make a semipermanent ruminal fistula. The technique has been generally satisfactory for market animals where salvage is the only object.

Prevention and Management of Bloat in the Feed Lot, Ivan L. Lindahl and R. E. Davis, U. S. Department of Agriculture

Knowledge of the causative factors of bloat is essential before logical treatment or preventive practices can be devised. Research on feed-lot bloat has been directed toward studying some of the causes of the bloat symptoms and of the differences among animals. Studies are far from complete. We have used only one general type of diet and still do not have a full understanding of the pathogenesis of the bloat symptoms resulting from this one diet.

The diet has been composed of 61% barley, 16% soybean oil meal, 22% alfalfa meal and 1% salt. In previous experiments, corn has been used in place of barley and alfalfa hay in place of the alfalfa meal. Results on the various feed combinations did not indicate that barley or alfalfa meal were more effective in producing bloat symptoms than corn and alfalfa hay. Alfalfa meal has been used in recent work, because it is easier to keep exact feed intake records when the meal is mixed with the other ingredients than when feeding grain and long hay. Barley has been used because of its reputation as a bloating grain.

There is a marked difference among animals in their susceptibility to feed-lot bloat, and this cannot be explained on the basis of feed or water consumption. The regular bloaters are prone to be slow and finicky eaters rather than greedy eaters. Many of the bloat symptoms develop before the animals finish eating and if marked enough, the animals will refuse to consume their full rations. Over a period of time the total feed consumption of the bloaters may be lower than for the non-bloaters.

The general development of bloat symptoms has followed a similar pattern over a period of two years and with 15 different individuals. First, we have found that there is a flurry of bloating just as the animals are switched over to the full feed of the bloat producing diet, the incidence of bloat then subsides for a week or so, and then gradually increases in incidence and severity for the next several weeks, although the feed intake remains constant. Some animals may bloat every day for a week or so and then suddenly quit for two or three days.

Although it is impossible to say that the strength of the ruminal contractions are normal in the bloating animals or that ruminal motility is not altered somewhat when the animals are switched over to the bloat producing diet, we have found that ruminal motility is quite active and that the contractions increase in frequency as the animals begin to bloat.

Studies on treatment and preventatives have involved the use of both in-vitro and in-vivo tests. The in-vitro studies have been directed toward measuring the effect of various substances on froth formation. The basic technique is as follows: A sample of ruminal contents is taken from each animal before feeding. The unstrained sample is then well mixed and 200 ml. are placed in each of a number of 500 ml. graduated cylinders. Three grams of dextrose is then added to each of the cylinders. One cylinder is taken as the control and the various test materials are then added to the remaining cylinders. All of the cylinders are placed in a water bath at 39°C. for a period of one hour. At the end of the period, the cylinders are removed from the bath and vigorously stirred. The change in the volume of the ruminal contents from the original 200 ml. is measured and recorded as percentage increase or decrease in the volume of stable ingesta.

In-vitro results can only be applied to clinical conditions with reservation. Data indicate that there is a correlation between the in-vitro tests and the incidence of bloat. Little or no increase in the stable volume of the ruminal contents occurs, under the conditions of the test, when animals are receiving non-bloat producing diets.

The results of in-vitro tests with detergents, methyl silicone, corn oil, turpentine, and kerosene showed that none of the detergents reduced the formation of froth and only one of the base materials appeared to be effective, however, this material did not completely prevent the formation of froth. Methyl silcone appeared to be more effective on the ruminal contents from some animals than from others, when used at the moderate levels. The high level of methyl silicone, turpentine, and kerosene not only prevented the formation of froth but broke up the existing froth in the original samples. The level of methyl silicone that was required to prevent the formation of stable froth in these tests was equivalent to 4 or 5 times the recommended therapeutic dosage. Corn oil was not effective on the ruminal contents from one animal, was quite effective in breaking up the froth in another case and had little effect in the other two cases.

In-vivo tests with preventatives are complicated by the fact that animals vary from day to day in bloat symptoms although management details and feed intake remain constant. A slight reduction in the average bloat index does not necessarily indicate that the preventative is effective in reducing the incidence of bloat. In in-vivo experiments with two detergents 1 fistulated and 5 intact animals were used. The detergents were dissolved in water and were administered by drenching the animals just previous to feeding. All animals were rated for the degree of bloating exhibited 1 hour after feeding. The fistulated animal was rated in the same manner as the other animals and then an exact pressure reading was obtained by using a mercury menometer. In short term experiments, up to 150 ml. of corn or cottonseed oil have been administered to two different animals before feeding and have not prevented the animals from bloating.

Methyl silicone preparations have not given satisfactory results in preventing the animals from bloating even when given in excessive amounts. A feed additive containing 50 g. of methyl silicone per lb. of material has been used in levels up to 200 g. per feed without preventing three different animals from bloating. This level is quite excessive when compared to the amount recommended for control of frothy bloat on pasture (4.5 to 18 g. per day). Liquid methyl silicone preparations did not prevent an animal from bloating when given at a rate of twice the recommended therapeutic dosage, although at other times this amount of silicone was effective in treating the same animal after it had bloated. So far we have not found a suitable material for the prevention of this type of bloat, once it has become chronic.

The substitution of long alfalfa hay for part of the bloat producing diet did not stop the animals from bloating. Animals that were shifted to all roughage diets or turned on to grass pasture did stop bloating, but began to bloat again when started back on the bloat producing diet. Studies on treatment of this type of bloat are incomplete. Methyl silicone in liquid suspension has appeared to be effective at times and non-effective at other times when administered to the same animal at rates up to twice the recommended therapeutic dosage. Tests with materials such as mineral oil, turpentine, or kerosene are not complete.

We have been able to release enough free gas with a stomach tube to result in a reduction in the ruminal distention. In order to determine the amount of free gas that could be released by stomach tube, we conducted an experiment over an eight day period with a fistulated steer that was a chronic bloater. One hour after feeding an intraruminal pressure reading was obtained by using an Hg manometer attached to the fistula cannula, and then a stomach tube of one inch inside diameter was inserted through the mouth and directed toward the dorsal blind sac. When the tube filled with frothy ingesta, it was withdrawn and a second pressure reading obtained. Over the period of 8 days, the average initial pressure reading was 19.0 mm. Hg and the average pressure after treatment with the stomach tube was 7.8 mm. Hg. The greatest reduction in pressure was 18 mm. Hg when the animal had an original pressure of 30 mm. and the smallest reduction was 6 mm. when the original pressure was 20 mm. Hg. Much of the remaining pressure was due to free gas. After the second pressure reading was obtained, the remaining free gas was slowly released from the fistula cannula and a third pressure reading taken. The average pressure remaining after release of all of the free gas was 2.8 mm. Hg. If the fistula cannula was opened rapidly, however, frothy ruminal contents would pour out of the cannula.

Treatment with the stomach tube has been only a temporary measure in a number of cases, as the animals would continue to bloat and be back to the pre-treatment stage in a few minutes.