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Role of Rumen Microflora in Ruminant Metabolism

LORRAINE S. GALL.
Senior Research Fulbright Grantee, Wallaceville Animal Research Station, Department of Agriculture, Wellington.

(Summary)

NEW ZEALAND is probably the most outstanding country in the world in the use of the ruminant as an economical producer of milk, meat and wool, so there is no need "to sell the rumen" to this audience. But because the ruminant is such an important factor in the New Zealand economy, it is especially pertinent to discuss the rumen and rumen function. The economical feeding of cattle and sheep depends on proper rumen function which in turn depends mainly on the rumen microflora—the active agents of digestion in the first stomach. Almost all of the food eaten by a ruminant is processed in the rumen, and it is not too far-fetched to say that when we feed a ruminant, we are feeding bacteria, and that the bacteria in turn feed the host ruminant.

The ration fed to ruminants is frequently deficient in available energy, B vitamins, and good quality protein, which if unchanged would present a poor form of nutrition to the animal. Fortunately the rumen bacteria with their various metabolic activities upgrade the ration in many ways. The most important function of the rumen bacteria is the conversion of the relatively unavailable energy of fibre into end products such as proprionic, butyric and acetic acids, which are readily acceptable to the host as food. Many of the rumen organisms synthesize B vitamins which are used by the ruminant for their requirements as well as by other rumen bacteria. Various forms of non-protein nitrogen present in the ration are used by the rumen bacteria to synthesize their cellular protein, which is made available to the animal when the bacterial cells are digested in the abomasum. These rumen functions are especially important as they are peculiar to bacteria and cannot be carried out by mammals. Proteins of low quality may be degraded in the rumen and synthesized into a higher quality protein by the bacteria and simple carbohydrates are fermented to form lactic acid, which may be changed into the lower fatty acids by other rumen bacteria. By these functions the rumen bacteria upgrade the inexpensive ration fed to the ruminant into a nutritious feed on which the animals thrive.

Since proper rumen function is so vital to the ruminant, it is necessary to understand what factors affect it. Several techniques have been devised to compare the rumen flora, environment, activity, and end products of animals on different experimental regimens. Rumen environment is determined by studying pH and Eh of rumen contents. Rumen flora is observed by means of Gram stains, and the isolated individual predominating bacteria are studied for their probable function in the rumen and their nutritional requirements. To date about 25 different broad groups of bacteria have been isolated among which are organisms able to perform all of the known rumen functions. In addition the activity of the rumen is determined with respect to the ability of the rumen organisms as a whole to break down fibre or protein in a miniature artificial rumen. The end-products of bacterial metabolism, such as proprionic, butyric, acetic and lactic acids, and B vitamins are assayed for quantitatively in the rumen fluid.

Such studies conducted with animals fed various rations in several localities with different water supplies, climate, and animal husbandry practices have shown that ration is the single most important factor in influencing rumen function. In the United States the feed of many classes of ruminants contains a large quantity of grain, especially maize. Experiments have shown that animals fed such a ration differ strikingly in rumen flora, environment, activity, and end-products formed when compared with animals fed mainly pasture and pasture products. It is readily apparent that animals fed too heavily on grain have a lowered rumen function.

In New Zealand the chief differences in feeding ruminants are differences in the varieties of pasture plants or in the stage of growth of the pasture, as affected by rainfall and temperature. How do these influence rumen function, since both factors influence the composition of the pasture? Limited data from experiments conducted at Manutuke where lambs were fed clover versus ryegrass, show that at 90 days of age, rumen environment, flora, and activity all are somewhat different in lambs fed clover as compared with those fed ryegrass, with a slight difference in lamb performance, in favour of the clover. The rate of growth of the pasture plant varied with the temperature during the winter months. Determinations of the rate of breakdown of fibre in miniature artificial rumens indicated that there may be greater activity in fibre digestion during the periods of faster pasture growth. From these data it is clearly indicated that the composition of the ration, and even of the pasture may influence rumen function.

Another factor which affects rumen function is the age of the animal. For a period immediately after birth, the young ruminant is essentially a simple stomached animal. The exact age at which the rumen begins to function and at what age the rumen is fully functional is still a matter of question. An experiment in which lambs are being studied from birth is in progress at the present time at Wallaceville. Partial results indicate that in these experimental animals, there is considerable rumen function established at three weeks of age, and that by two months of age the rumen functions are well, if not completely, established, as judged by determinations of rumen flora, environment and activity. More studies will be needed under other conditions before this question is finally answered.

What use can be made of an understanding of the role of rumen organisms in ruminant metabolism? First, it is important to realise that a ruminant has a very wonderful specialized digestive tract, especially designed to utilise inexpensive fibrous food. This should be fully appreciated and made use of in all ruminant industries. Secondly, it is well to remember that the ruminant's ration must be designed to feed bacteria and the general requirements of feeding bacteria must be kept in mind. Bacteria, because of their synthetic activities, are less expensive to feed than animals, but their limited storage capacity, special nutritional requirements, and other peculiarities must be considered. A true understanding of the rumen organisms and their role in ruminant metabolism should lead to better rumen function, more economical production, and a better and thriftier ruminant industry.

Discussion

Mr. WHITTEN: Could Dr. Gall give us some more details on the concept of feeding the bacteria in the rumen?

Dr. GALL: Bacteria have rather specialized nutrient requirements stemming from the fact that not only the specific nutrient must be supplied, but the nutrients must be present in the proper balance. In addition the nutrients required by the bacteria must be available simultaneously as the bacterial cell has a very limited storage capacity. Thus the specification of the percentage of a certain nutrient present is of less value than the relative availability of that nutrient. These factors must be taken into account when feeding rumen bacteria.

Dr. MELVILLE: How does the ruminant extract the nutrients from pasture so efficiently when the same process in vitro is so difficult?

Dr. GALL: The rumen bacteria by their specialized enzyme system are admirably suited to digest pasture and make the nutrients available to the host ruminant, either in an unchanged condition or in an altered condition due to bacterial metabolism. Fortunately most of the changes in the nutrients due to bacterial metabolism seem to be of benefit to the ruminant.

Mr. REID: How do you measure the levels of proteolytic activity?

Dr. GALL: A test using the permeable-sac type of artificial rumen with zein as a substrate and rumen liquor as an inoculum is under study. The rate of disappearance of the zein is measured. The method for the test is not completely established at this time.

Dr. CUNNINGHAM: Was the intake measured on the lambs on white clover at Manutuke? How is fibre digestion measured? How could we feed the organisms properly under New Zealand conditions?

Dr. GALL: No, the intake of the animals at Manutuke was not measured. Fibre digestion was measured in the miniature, artificial rumen. The organism could be properly fed in New Zealand by supplying the animals at all times with a sufficient amount of good quality mixed pasture and pasture products. This pasture should supply the known nutrient requirements of rumen organism in the proper balance in a readily available condition. Special attention should be paid to a proper balance of energy and protein, and an adequate supply of minerals, both macro and trace; and to ensuring the presence of enough of the three X-factors carried in rich supply in leguminous plants which are stimulatory to several important rumen organisms.

Dr. FILMER: Could Dr. Gall suggest why fresh spring pasture or dry summer pastures are more satisfactory for sheep than fresh autumn pasture or the lush pasture that grows in a wet summer? The summer and autumn pasture is similar to the spring pasture in chemical composition.

Dr. GALL: My experience with this question is extremely limited. I can only postulate that the difference may lie in the preparation of the rumen to handle the pasture at the two different seasons. From my limited observations it would seem that the green winter pasture may be more similar in composition to the spring flush that follows than the dry summer pasture is to the autumn flush. This would mean that the rumen in spring was better able to handle the spring flush because it was better prepared through previous feeding of a more similar type of pasture. The autumn flush might find the rumen poorly prepared to handle the pasture because the summer pasture was of different composition. Any sudden change in feed is apt to cause difficulty because of an unprepared rumen flora.