THE LENGTH OF THE INTESTINE OF CALVES AND ITS BEARING ON THE ABSORPTION OF THE NUTRIENTS FROM THE CHYME[1]

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In his recent book (1) Alvarez states, "Meat-eating animals have a simple stomach and colon and a short bowel, whereas grass-eating animals usually have a complicated stomach and colon, a large cecal pouch, and a long, small bowel. In carnivorous animals the small bowel is said to be only from four to eight times the body length, while in herbivorous animals it is from twenty-five to seventy-five times the body length." According to Swett and Graves (15) the length of the small intestine of mature beef cows (eight animals) varies from 93 to 140 feet and that of dairy cows (two animals) from 144 to 172 feet. From these data one finds that the post-mortem length of the small intestine of beef and dairy cattle is 28 and 33 times, respectively, the length from withers to pin bones, or within the lower limit suggested by Alvarez. The length of the large intestine of the same animals varies from 23 to 41 feet for beef animals and from 43 to 46 feet for dairy animals.

Black, Semple and Lush (2) found that the average length of the small intestine of 20 seven-months old range steers was 98 feet. One hundred and twenty days later the average length of the small intestine from a similarly bred group (32 animals) had increased to 110 feet. The average length of the large intestine for both groups was 21 feet. Such figures, of course, are only approximate in that the changing tone of the musculature of the intestine makes an exact figure impossible.

Data concerning the length of the intestine of a live calf has only been reported on one animal (6). In this instance the length of the small intestine of a six months old calf was found to be 21 feet two inches in the living animal and 68 feet nine inches on removal from the body. Since that time the following data shown in table 1 have been accumulated:

From these data it is apparent that the length of the small intestine of the living calf is about seven times its body length, a figure somewhat out of line with that suggested by Alvarez.

What influence this greater length of the small bowel has on digestion can be better understood by studying the movement of chmye in the gastrointestinal tracts of carnivora and herbivora. Heile (10) states that in dogs on a mixed meal, material began to appear at the lower end of the

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TABLE 1

Length of small and large intestine of calves in vivo and post mortem

Calf number	Age in mo.	Length of small intestine				Length of large intestine			
		In vivo		Post mortem		In vivo		Post mortem	
		Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
47A4	5	23	3	77	1				
47R	9	20	1	53	4	7	6*	12	10*
1698	12	17	2	68	10	7	1	14	8
1704	10	25	5	81	1	7	2	16	10
Previously reported (6)	6	21	1	68	9				
Average		21	5	69	10	7	2	15	9

* Data do not include cecum. Consequently figures have not been used in calculating average.

small bowel one hour after feeding and by the fifth hour the small bowel was empty. With a diet rich in carbohydrates and fats, the time required for digestion and elimination from the stomach and small intestine was only three to four hours. Assuming the usual time for digestion in the stomach of dogs, it is apparent that the absorption of the digestible portion of the meal and the elimination of the residue into the large gut occurs within an hour after the food enters the small intestine. In other words, if the average length of the small bowel is about four feet (1, 3) the chyme must be moving through this part of the intestinal tract at an average rate of at least four feet per hour.

Comparable data for ruminants are not available. Dickey (4) found that the first part of a meal of milk passed through the entire gastrointestinal tract of young calves in 30 hours while Fish (8) reported that the first of a dye marked feed offered to mature cattle passed through the gastrointestinal tract in 16 to 17 hours. The time required for the passage of all the food residues from one meal through the digestive tract of herbivora may require several days (5). Ewing and Smith (7) claim that during most of this time the food is in the rumen. It is entirely probable that the first residues to reach the anus from any one meal are from food which has not been detained long in any part of the stomach. The average time for the major portion of the food to pass through the gastrointestinal tract of mature herbivora probably is about 72 to 84 hours, depending on the amount and type of feed, its physical condition, and certain physiological reactions in the animals (7). What then is the rate at which the food residues pass through the various segments of the intestine?

Available information would indicate that food nutrients other than the fiber fraction are equally well absorbed by ruminants and non-ruminants despite a difference in the length of their respective intestinal tracts. Due to the physical effect of the fiber the progress of food through the small

intestine of herbivora is probably faster than for carnivora. In fact, this would seem logical from two unrelated bits of evidence. First, Krzywanek (12) and others (9, 11, 16) found that the rate of travel of the ingesta is speeded up by giving food at frequent intervals. The act of filling the stomach also increases the motility of the colon, frequently to the point of causing immediate defecation. With ruminants it is a well known fact that food from the first two compartments of the stomach is emptied into the abomasum at frequent intervals. This frequent stimulus may aid in the more rapid progress of the chyme through the bowel of the ruminant as compared to that of the non-ruminant.

A factor of even more importance in increasing the rate of passage of food through the bowel is the fiber content. Foods rich in cellulose tend to pass through the small bowel faster than low fiber feeds (13, 14). This in itself may explain why a ruminant needs a longer small intestine, relatively, than a dog in order to utilize its feed efficiently.

It has been the experience of the investigators that high fiber material, as used in most "milk substitutes," tends to cause young calves to scour. Unground or coarsely cut roughage does not have this effect, probably because it is held in the rumen until partially "digested." This predisposition to scour on ground high fiber feeds vanishes as soon as the first three compartments of the stomach have reached sufficient size to hold back one or two days' food supply until acted upon by bacteria and the rumen fluid. Apparently, the intestine of the young calf is quite sensitive to large amounts of fiber. Although the small intestine of the ruminant is two to three times as long, relatively, as that of the non-ruminant, this additional length is not sufficient to provide for the efficient use of high fiber feeds unless thoroughly comminuted in the rumen and passed into the abomasum in small amounts. Grinding of the feed cannot replace this action of the rumen.

The large intestine of the ruminant is relatively short. In that its length is comparable to that of the large bowel in carnivora, there is no reason for believing that it plays an active part in the utilization of a high fiber feed.

SUMMARY

The small intestine of the living calf is about seven times the body length, or about one-third the post-mortem length. Variations in the ratio between body length and length of intestine depend more on individuality than upon the age of the calf. Although the progress of the chyme through this region is comparatively rapid, the increased length in ruminants allows for proper absorption of the nutrients if thoroughly comminuted in the rumen.

The large intestine does not show as great a difference in length between the living and post-mortem stages as does the small intestine.

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