CC/NUMBER 7
FEBRUARY 14, 1983

This Week's Citation Classic

Conrad H R, Pratt A D & Hibbs J W. Regulation of feed intake in dairy cows. I. Change in importance of physical and physiological factors with increasing digestibility. *J. Dairy Sci.* 47:54-62, 1964.
[Dept. Dairy Science, Ohio Agricultural Experiment Station, Wooster, OH]

Feed intake of ruminants is controlled either by the limits of physical capacity of the body or a multiplicity of coordinated physiological pathways which are largely energized by metabolites of food and neural feedback systems. It was found that physical and physiological factors regulating feed intake changed quantitatively with increasing digestibility of food. At low digestibility they were: physical capacity, rate of passage of undigested residue, and proportion of feed digested. At higher digestibilities intake depended on metabolic size, productive energy, and digestibility. [The *SCI*® indicates that this paper has been cited in over 145 publications since 1964.]

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December 30, 1982

"In 1962, while studying with Max Kleiber at the University of California in Davis, California, I formulated the theoretical basis for the cited paper. An objective was to describe the physiological components for the variances in feed intake in cattle. This paper may be highly cited due to the fact that we set forth in two equations the expected changes in feed intake of ruminants between starvation and hyperphagia. The equations are uncomplicated and appear to have provided comprehensible models for other investigators to use in developing their working hypotheses.

"Initially, my interest was in computing maximum feed intake of ruminants eating fibrous diets. The curvilinear regression equation proved insensitive to important variances. It occurred to me that Kleiber's[1] mathematical models for various allometric relationships would provide a simpler model for expressing the capacity for food in cattle in which their physical structure provided limited space. In a short while, the terms for evaluation of abdominal space for feed in cattle were discovered and separated from the metabolic terms describing the achievement of general satiation by absorbed nutrients and other chemicals effecting changes in the central nervous system.

"The data for this study had been collected in Ohio during a ten-year period with my colleagues, Avery Pratt and John Hibbs. It was evident to us that the effects of plant chemistry on feed intake were modified by the yield of milk energy in cows. It was equally clear that restrictions on feed intake, whether they arise inherently from chemical and physical characteristics of the feed or the anatomy and physiology of the cow, represent the most obvious practical limitations on milk production.

"The influence of previous investigators always comes into play when natural laws are newly discovered. The contributions of Kleiber,[1] K.L. Blaxter,[2] and F. Lehmann[3] were influential in this case. I am not certain if Kleiber knew fully how important his findings on relative feed capacity[1] were to the formulation of the concepts of the cited paper. When I presented a seminar at the Davis campus describing the new equations, the room was uncomfortably warm and Kleiber, who was past 70 years of age, fell asleep. In 1962, Blaxter was among the leading theoreticians investigating ruminant nutrition. Particularly helpful was his finding[2] that the feed intake of sheep was regulated by the rate of passage of indigestible residue through digestive tracts of limited capacity. Recent work in the field has been reported.[4]

"This paper was among ten scientific articles cited in 1966 by the American Dairy Science Association for the Borden Award."

1. **Kleiber M.** *Fire of life.* New York: Wiley, 1961. 449 p.
2. **Blaxter K L, Wainman F W & Wilson R S.** The regulation of food intake by sheep. *Anim. Prod.* 3:51-61, 1961.
3. **Lehmann F.** Die Lehre Vom Ballast. *Z. Tierernahr. Futt.* 5:155-9, 1941.
4. **Conrad H R, Balle C A & Mayer J.** Changing meal patterns and suppression of feed intake with increasing amounts of dietary nonprotein nitrogen in ruminants. *J. Dairy Sci.* 60:1725-33, 1977.