gene in the replacements for the herd. However, under present conditions, the pedigree discrimination that would be encountered in attempting to sell breeding stock offers little, or no, incentive to a breeder to attempt to clean up a herd with a dwarfism history.

Summary

Data are presented on three years study of the x-ray technique for detecting carriers of the snorter dwarf gene. Approximately 80 percent of the dwarf carriers x-rayed as young calves at the Ft. Reno Station were correctly classified from x-rays of their lumbar vertebrae. It was also observed that 20 percent of the calves from a herd believed to be free of dwarfism were classified as carriers from their x-rays.

The x-ray method is not considered accurate enough to serve as a basis for merchandising beef cattle. It can be useful in early screening of prospective breeding animals in a problem herd. However, its practical application is limited by the pedigree barrier against animals from such herds.

Snorter dwarf calves have very characteristic abnormalities of the lumbar vertebrae that have never been observed in non-dwarf calves. Lumbar x-rays accurately identify a dwarf calf, and may be very useful to breeders in determining the dwarfism status of a doubtful calf.

Contributions of Nutrition Research to Animal Production

ALLEN D. TILLMAN

Is the present-day animal nutritionist overly optimistic when he gazes into his crystal ball and predicts the effects of future discoveries upon animal production? If we look back over the past 60 to 70 years, we can readily see that at no time within this period was he optimistic enough in forecasting the enormous impact of nutritional discoveries on present-day animal production. These discoveries have made it possible for fewer farmers to produce more meat, milk and eggs upon fewer acres of land. But we must do better. When you sit down at your dinner table this evening, there will be over 35,000 more people to join you than there were at breakfast.

Important Past Discoveries in Nutrition

To better understand the importance of basic nutrition research, and to make some predictions of future happenings in this field, we must review some of the discoveries and concepts of the past that have greatly influenced the field of animal nutrition. Along these lines, let us consider the development of the purified diet concept and its effect on nutritional discoveries and important past discoveries in vitamin, protein and mineral nutrition.

1. PURIFIED DIET CONCEPT. In the year 1830 a British physician named William Prout stated that there were what he called

three staminal principles which provided the essential nutrients for animals. These principles were carbohydrate, protein and fat. Prout's idea was not seriously challenged by research workers until around 1900. During the next 10 years, several workers reported that animals fed diets composed of pure protein, carbohydrate and fat soon died and exhibited certain disease symptoms. The inclusion of minerals in the diet gave only slight improvement, but the inclusion of natural feeds of vegetable or animal origin resulted in a dramatic response in all animals. These observations led one worker to sum up the work thusly: "No animal can live on a mixture of pure protein, pure carbohydrate and pure fat, and, even when the necessary inorganic elements are carefully added, the animal cannot live. The animal body is adjusted to live either upon plant tissues or other animals, and these contain countless substances other than protein, carbohydrate and fat." He coined the term "accessory food factors" for these postulated substances.

The purified diet technique, which was accepted around 1900, has been the basis for many of the important discoveries in nutrition. The present-day purified diet contains 50 or more purified nutrients. Each can be included or omitted individually. Thus the researcher can omit one or more nutrients at a time to study the effect of this omission on the animal. By this technique it is now possible to associate certain diseases occuring in animals with the deficiency of one or more nutrients in the ration of that animal. Also, by varying the levels of a nutrient in the diet and measuring performance (growth, fattening, reproduction, etc.) of the animal, research workers can establish the quantitative requirements of animals for each of the various nutrients. The results of tests using this technique were and are being used for establishing feeding standards.

The purified diet technique also is used to study the effects of *nutrient imbalances.* This important type of study will be considered later in this paper; but, at this stage, it should be emphasized that our now meager information indicates that nutrient imbalance is one of the most complex problems in modern nutrition research. If we knew the effect of each nutrient upon the animal's utilization of each of the other nutrients, we could perhaps explain why certain forages produce such poor results when they form rations of range cattle and sheep. The purified diet technique offers an approach that will someday answer this acute problem.

2. RECOGNITION OF VITAMINS AS ESSENTIAL NUTRIENTS. The reason the researchers were unable to grow animals on a purified diet composed of purified protein, carbohydrate, fat and certain mineral elements was furnished by a Polish chemist named Funk in 1912. Working in England, Funk cured rats of polyneuritis by the administration of a water extract of rice bran. Upon closer examination of this extract, he found that it contained a chemical entity called an amine. Recognizing the profound nature of this discovery, Funk immediately reported that he had found a substance that was essential for life ("Vita") and that it contained an amine group. Combining these terms, he named the new substance "vitamine." Re-

searchers on the European continent, as well as those in America, within a very short time recognized similar substances that did not contain an amine group, thus, the name was later changed to "vitamin" which still serves as a group name for some 16 chemically and physiologically unrelated compounds that are required in very small amounts for the well being of all animals. Many of the important vitamin discoveries that have resulted in improved nutrition of animals are as follows:

a. Elucidation of the physiological effects of a deficiency of vitamin A. (1914-1940)

b. Synthesis of vitamin A. (1946-1948)

c. Stabilized vitamin A. (1949-1956) The feed nutritionist is now, for an almost negligible cost, able to fortify all rations for all livestock.

d. Discovery of vitamin D. (1922)

e. Discovery that cod liver oil contained vitamin D (1922), allowing the keeping of animals indoors the year around.

f. Discovery that the vitamin D potency of feeds could be increased by exposure to ultraviolet light (1924). Greatest impact in human nutrition in the improvement of milk.

g. Dry sources of stable vitamin D. (1940-1944)

h. Separation of the vitamins contained in the designated "Water Soluble B" fraction. (1930-1950)

i. Discovery of the importance of supplementary B-vitamins (choline, nicotinic acid, pantothenic acid and vitamin B_{12}) in practical poultry, swine, and turkey rations. (1945 to present time)

j. Discovery of vitamin B_{12} and more importantly a discovery of low-cost source of vitamin B_{12}. (1949)

k. Discovery of economical sources of B-vitamins needed in supplementing practical rations fed to swine, chicks and poults. (1948 to present time)

l. The effect of high-energy rations for chicks and swine upon the vitamin requirements of these animals. (1950 to present time)

3. PROTEIN DISCOVERIES THAT HAVE RESULTED IN IMPROVED NUTRITION OF ANIMALS. The field of protein nutrition is older than that of vitamin nutrition. Nevertheless, there are many more gaps in our knowledge of protein chemistry and we have made less progress in transferring our basic knowledge to practical feeding. But we are making progress. Many important discoveries made within the past 50 years have had a great impact upon practical feeding of animals and many more will come in the future.

Many of the important discoveries in protein chemistry and nutrition follow:

a. Discovery that the nutritive value of some proteins was improved by the addition of certain amino acids. (1905-1914) This basic discovery spurred the protein chemist and nutritionist to study the amino acid makeup of different feed proteins.

b. Discovery that the simple stomach animals were unable to synthesize at a rate required for normal growth 10 or more of the amino acids found in body protein. These amino acids were termed "dietary essentials" to distinguish them from those 12 or more amino acids found in body protein that can be synthesized within the body from the dietary essential amino acids. (1930-1940) This concept, which developed from the results of many basic researches, is fundamental to our understanding of protein nutrition today. This important concept, derived from literally hundreds of individual research projects, set the stage for research work designed to evaluate all protein systems on the basis of their essential amino acid contents.

c. Discovery of supplementary relations between various protein systems relative to their essential amino acid contents. (1945 to present time) It was found that proteins of vegetable origin differed in their proportions of essential amino acids and that in many cases one protein system contained an abundance of an essential amino acid which was deficient in another protein system. Thus, a combination of the two protein systems gave greater growth than either fed individually. Prior to this discovery, the practical feed nutritionist, compounding rations for the simple stomached animals, used only protein supplements of animal origin such as meat scraps, milk, etc. The dietary supplements of animal origin have an amino acid content closely resembling that of the new tissues they will form in the animal, and therefore, have a high value for promoting growth. The supply of protein supplements of animal origin has always been limited and this one factor limited swine and poultry production for many years. Then it was discovered that soybean meal contained an abundance of the essential amino acid, lysine. Further research showed that an "all vegetable protein ration," if the protein supplement were soybean meal, properly fortified with vitamins (particularly B_{12}, riboflavin, niacin, choline, and pantothenic acid) and minerals, promoted gains in swine and poultry equal to those obtained when the animal protein supplements were fed these animals. This discovery, which was the culmination of much individual research, is undoubtedly responsible for the unprecedented expansion of swine and poultry production in this country. The producers of

these animals today would not consider the possibility of growing their animals on rations devoid of soybean meal any more than the producer of yesteryear would have considered doing without an animal protein supplement.

d. Improvement of soybean oil meal. (1940 to present time) Raw soybean contains much protein but this protein is of poor quality. That is, it supports very slow growth when fed to the simple stomached animal. The basic research work by a German immigrant in this country gave the nutritionist an idea which led to the improvement of soybean protein. This worker, in a very impractical experiment, designed a purified diet in which the protein was supplied by *pure* essential amino acids. In one of the basal rations, he deliberately omitted one of the essential amino acids and then allowed the animal to consume this diet. At definite intervals of time after feeding, he then force-fed enough of the omitted essential amino acid to make the mixture complete in regard to protein synthesis. His astounding results showed us that for protein synthesis to proceed at a maximum rate, all of the amino acids have to be present at the same time. As all proteins, when digested in the gastro-intestinal tract, are broken down to amino acids and absorbed as such into the blood stream, nutritionists immediately foresaw the possibility that if some substance in a protein system should slow down the absorption of any essential amino acid, the growth promoting value of that protein would be hindered. It was soon discovered that raw soybeans contained a substance that hindered their digestibility and that this substance was destroyed by heat. Too much heat, however, also reduced the protein quality of soybean oil meal. Thus, researchers had to find out how much heat was necessary to destroy the inhibiting material without reducing protein quality. After much basic research on this problem, there evolved the present-day high quality soybean meal, which is produced under very closely controlled temperatures.

e. Protein substitutes for ruminant feeding. (1941 to present time) Urea is now widely used as a protein substitute in rations of cattle and sheep. Discovery of the factors necessary for the proper utilization of the non-protein nitrogen compounds has been and still is a very interesting field of research.

f. Low cost fiber sources for ruminants. (1950-1956) At the present time, we are using low-quality roughages such as cottonseed hulls, cotton gin trash, corn cobs, corn stalk, etc. for feeding ruminants. The development of supplement necessary to supply nutrients missing in these roughages has been an interesting and profitable research endeavor.

g. Synthetic DL-methionine and analogues. (1950-1955) Most natural rations have a slight deficiency of the essential amino

acid, methionine. Thus, the discovery of economical sources of it has improved the feeding of chicks and poults.

4. DISCOVERIES IN MINERAL NUTRITION. Minerals are needed as structural elements in the skeleton of the body and as biological catalysts in the utilization of certain organic nutrients; carbohydrates, fats and proteins. Some of the important discoveries in mineral nutrition are as follows:

a. Discovery of new mineral sources supplying calcium and phosphorus. (1942 to present time) The simple stomached animals do a poor job of utilizing the phosphorus in vegetable feeds; therefore, their rations must have additional inorganic phosphorus. The present-day supply of steamed bone meal is too small to support our enormous swine and poultry enterprizes.

b. Discovery of the importance of cobalt in ruminant nutrition. (1938-1955) Cobalt in ruminant rations is necessary for the formation of vitamin B_{12} in the rumen of these animals. A 1,000-pound cow requires approximately 1 milligram daily. The use of radioisotopes made this discovery possible.

c. The elucidation of the importance of other trace elements in animal nutrition. (1938 to present time)

d. The interrelationship of calcium and zinc in the prevention of swine parakeratosis. (1955 to present time)

e. The importance of phosphorus in ruminant digestion of fiber, thus allowing the utilization of low cost roughages. (1954 to present time)

f. New methods of determining mineral availability by the use of radioisotopes. (1948 to present time)

g. Discovery that added sulfur was needed when urea was a major source of nitrogen in a ruminant ration. (1946-1950)

5. OTHER DISCOVERIES IN WHICH THE ANIMAL NUTRITIONIST HAS PARTICIPATED. The nutritionists have also participated in discoveries that cannot be classified under the preceding headings. Nevertheless, these discoveries have aided animal production and are as follows:

a. Disease control through medicated feeds. (1950 to present time)

b. The effects of certain hormones upon livestock gains. (1950 to present time)

c. Development of a proper calorie to protein ratio for the feeding of livestock. (1955 to present time)

d. The establishing of nutrient requirement tables for better feeding of animals.

e. Nutritional improvement of barley by water treatment or by the addition of enzymes. (1957)

Present Discoveries That Are Promising But Need More Study

Many of the present discoveries show much promise of having practical application in animal production. These discoveries, which follow, need to be studied more before a general usage of each item is advocated.

a. Enzyme feeding to pigs and chicks.

b. Injectable iron-copper compounds for baby pigs.

c. Amino acid supplementation with amino acids other than methionine.

d. Interrelationship between vitamin E and selenium in nutrition.

e. Use of tranquilizers in animal feeds.

f. Thyroid feeding to brood sows.

g. Stilbestrol feeding to all animals.

Future Discoveries

Approximately 200 nutrition and biochemistry laboratories in this country are doing research on basic and applied problems of nutrition. In these laboratories, about 800 qualified scientists are working in some phase of research. It is only reasonable to assume that newer discoveries with resultant changes in concepts, methodology, and production goals will come from these workers. Some authorities estimate that only 30 to 40 percent of the basic nutritional findings have been uncovered and that many of these may never be discovered. However, covered, and that within the next 25 years, we should see many important discoveries of a basic nature. What are likely to be the most important nutritional discoveries in the future? Here are some possibilities:

a. Establishment of complete optimal and minimal nutritional requirements of all essential nutrients for body functions. (A whale of a job.)

b. Discoveries of newer and cheaper sources of feed nutrients such as microbial residues, algae, dried sewage, new plants, etc.

c. Discovery of ways to produce hormones that will allow greater production of meat, eggs and milk more economically than at the present time.

d. Discoveries improving the nutritive value of important animal products such as eggs, milk and meat, thereby improving the value of these products for human consumption.

e. Discoveries improving the efficiency of ruminant animals. It is now known that ruminants are less efficient converters

of energy than are the simple stomached animals. A large part of the difficulty lies in our inability to balance rations for the microorganisms living in the rumen. Recent research results suggest that the relative proportions of fatty acids produced in the rumen and which are available for the host animal can be varied by altering the composition of rations. Thus it is feasible to assume that a certain proportion of fatty acids will produce milk more efficiently while another proportion of fatty acids will produce fat or growth more efficiently. If these can be worked out, we shall be able to "tailor make" our rations for a given function and improve the efficiencies of these animals.

f. Discovery and classification of antimetabolites contained in feeds for ruminants. Knowledge of this nature might explain why certain forages produce poorer growth than others. Also, there might be ways of economically removing or counteracting these compounds which directly interfere with the metabolism of certain nutrients.

g. Basic discoveries of metabolic roles of nutrients in the body. When all the metabolic functions of a nutrient are established, research workers will be able to study factors affecting these functions. From studies with whole animals, we know that certain nutrient imbalances do affect growth of the animals. But we do not know how too much of one nutrient affects a specific metabolic function of another nutrient. With such information on all nutrients it might be possible to integrate this knowledge and to eventually compound a perfectly balanced ration.

In this space age, our attentions are constantly drawn to future exciting adventures out beyond the earth. No less exciting will be the new discoveries and developments in animal nutrition. As these discoveries are made and are put to use by the animal production men, our collective goal of producing more meat, milk and eggs that will sell for a price which both the producer and consumer can afford will come nearer to full realization.

Management Practices to Increase the Lamb Crop from Spring Bred Ewes

JOE V. WHITEMAN AND RICHARD PITTMAN

Most commercial lamb producers in Oklahoma try to produce and sell "spring" lambs. This system of production involves breeding the ewes so that most of the lambs are born in the fall. There are several advantages to managing the sheep flock in this manner.

1. The lambing season can be timed to come when the sheepman has the necessary time to care for the ewes.