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PROBLEMS IN THE FIELD OF ANIMAL NUTRITION[1]

PROGRESS in the profession of animal production is obviously determined by our understanding of the facts and principles upon which it is based.

Having proceeded along lines of least resistance, for a certain time, limits to advancement are reached such that continued progress depends upon the solution of certain commanding or "key" problems. In the service of the profession, and of the nation, the sub-committee on animal nutrition of the National Research Council wishes to call attention to some of these more important problems, with which we are in immediate contact.

In so doing it is our hope that the problems will appeal to research workers in such ways as to result in extensive informal cooperation in their solution, simply through the choice of specific subjects for research within the general field as outlined.

However desirable is close cooperation in research work there may be great practical difficulties in providing for and in accomplishing such a relation. It seems practicable, however, at least to bring about a useful degree of correlation in research by inviting the choice of subjects for study from large projects having importance sufficient to commend them to experimentors and administrators in this field of endeavor.

We would indicate, therefore, the following problems and fields of research as worthy, in our opinion, of extensive and thoroughgoing study:

I. A general program of research on foods of animal origin in relation to human nutrition and to agriculture.

II. Growth curves of farm animals.

III. The establishment of a scientific basis for judging farm animals.

[1] By the sub-committee on animal nutrition, National Research Council.

IV. The estimation of metabolic nitrogen as a contribution to the perfection of feeding standards.

V. Mineral requirements of farm animals.

VI. Vitamin requirements of farm animals.

VII. Diet and reproduction.

I. A GENERAL PROGRAM OF RESEARCH ON ANIMAL FOODS IN RELATION TO HUMAN NUTRITION AND TO AGRICULTURE

Viewed in the largest and most general way, the human diet must contain a large proportion of cereal foods—for economic reasons.

Cereal products, however, are far from complete foods. Consider, for instance, white flour and refined sugar—perfect foods of their sort, and permanently established in the diet. In themselves they are in no way harmful; in many ways and for many purposes they are unexcelled; but these and other cereal products are among the most deficient of foods in a number of essential nutrients. In fact one of the most important dietary problems confronting civilized man to-day is that of restoring the balance of essential nutrients which has been disturbed by the prevailing use of cereal products.

Since human beings will always consume large amounts of cereal foods, a factor of surpassing importance is that portion of the diet which supplies the essential nutrients in which they (the cereal foods) are deficient.

The classes of foods best qualified to supply these deficiencies are especially the animal foods, meats, milk and eggs, but also fruits, nuts and vegetables.

The costs of production of foods of vegetable origin, in terms of land and labor, may be grouped together, as of similar magnitude.

The costs of production of the highly desirable foods of animal origin are very much greater; so that, in times of economic stress, and as increase of population gradually overtakes the possible food supply, the terms upon which animal foods may be had becomes a matter of very great and of increasing importance.

While all animal foods are relatively expensive they differ much in land and labor costs, and also in nutritive values, dietetic uses and general economic significance, through relation not only to land and labor, but also to transportation, marketing, cropping systems and fertility of the soil.

The objects of this project are (1) to determine the proper place of animal foods, as a group, in the human diet; (2) to establish the facts as to the specific nutritive and dietetic functions of meat, milk and eggs; and (3) to show the position and relationships of the several types of animal food production in the national system of agriculture.

With these points in mind we propose the following outline for an extensive program of researches on food of animal origin.

OUTLINE OF RESEARCH

(1) Human nutrition:

a. The place of animal foods in the diet, in infancy, childhood, maturity, reproduction, senescence, sickness, labor, war and sedentary life; limits of dietetic interchangeability of animal foods.

This group of problems in practical human dietetics has always been, and always will be. We have reached an age, however, in which progress in their solution is possible at rates vastly greater than in any earlier era; and these great problems must be kept constantly before research men in order that no opportunity may be overlooked for contributing to their solution through the undertaking of definite projects of properly limited scope.

The necessary backgrounds for such researches, in the way of laboratories, groups of competent investigators, and institutions of various sorts providing satisfactory groups of experimental subjects, are not uncommon; but men who are able and interested to organize and to conduct such investigations, and who can command the necessary human cooperation, are rare. The more honor then to him who succeeds in this most important field of service.

b. Nutritive values of animal foods as supplementary to other components of mixed diets.

The superiority of animal foods, for supplementary purposes, varies much with the natural food-habit of the kind of animal under observation. It is especially prominent with poultry. It is not so with herbivora. The desirability of experimenting with human beings directly, before drawing final conclusions, is obvious.

c. Nutritive values of constituent compounds,

especially the proteins, of foods of animal origin.

The investigation of this group of problems, in the laboratory, with small animals as subjects, will throw much light, by inference, upon problems of human nutrition, and will afford valuable guidance in the planning of experiments with human beings as subjects.

d. Healthfulness of animal foods, as affected by contamination and infection.

More definite information is needed as to the viability of the pathogenic organisms which may be carried by foods of animal origin, as affected by the various methods of preparation and use.

e. Composition of animal foods—amino acids, non-amino nitrogen, fats, phosphatids, inorganic compounds, vitamins; methods of separation and purification of constituent compounds.

Immediate interest would attach to further determinations of the presence of vitamins in various meats and to the iron contents of the same.

(2) Agriculture:

The ever-increasing congestion of population upon the earth renders increasingly important the realization by every man of the nature of his dependence upon agriculture, and of the nature of the complicated agricultural situation upon which he depends.

A series of researches on the subjects here suggested, and the promulgation of the facts derived and assembled, must have a most salutary effect, not only as a stabilizing influence with the man in the street, but particularly through broadening the understanding of some of the leaders among men, who are "educated beyond their information."

This outline is intended to call attention to the fundamental and essential relations of one kind of animal food production to another, and of animal food production, in general, to agriculture.

a. Physiological economy of production of animal foods, considering the entire life of the animal and the entire business of production.

b. Relative draft upon or contribution to soil fertility of various systems of animal food production.

c. Relative proportions of feeds used in various systems of animal food production which are usable by human beings.

d. The utilization of manufactory by-products, farm wastes and unmarketable forage in various systems of animal food production.

e. Systems of animal food production as means of saving cost of transportation of feed.

f. Relative costs of transportation and marketing of various animal foods.

g. Production per acre of land, in various systems of animal food production.

h. Relative labor requirements of various systems of animal food production.

i. Relation of systems of animal food production to cropping systems.

II. THE GROWTH CURVES OF FARM ANIMALS

Throughout our research work in the feeding of animals the results would gain much in value and significance if it were possible to compare them with normal standards.

The development of the vitamin hypothesis, and of the modern doctrine of protein metabolism have been greatly facilitated by the establishment of normal standards, in the shape of growth curves, for the experimental animals used.

Similar normal curves of growth should be determined for all breeds and types of animals of economic value.

These will be of especial service as means of comparison in making graphic representation of the results of studies of breeds, individuality, rations and supplements, in relation to growth, lactation or other performance.

III. THE ESTABLISHMENT OF A SCIENTIFIC BASIS FOR JUDGING FARM ANIMALS

Our present standards of livestock selection rest upon the cumulative experience of many centuries of livestock breeding, the practical judgments of the markets for animal products, and the conventional specifications of the breed associations.

To only a slight extent do these standards rest at present upon results of systematic and orderly studies by the methods of science.

In our opinion the subject of livestock judging is of such practical value and has such appeal to the interest of the student that it can not be spared from the college curriculum; but it is also our opinion that it can not continue indefinitely to hold its own on the present basis.

A scientific foundation should be established

for livestock judging, based upon a critical study of the entire subject from the standpoints of the anatomy and physiology of the animal, and also upon the determination of the correlations existing between the measurable proportions and functions of animals, by the methods of biometric research.

The following specific problems for investigation are suggested as illustrating the point of view expressed:

1. A study of factors which influence the apparent spring of ribs.
2. Conditions of the eyes of animals, and what they indicate.
3. Qualities of hair and hide of animals, and what they indicate.
4. Indications of conditions as to texture of flesh of meat animals.
5. Indications of conditions as to density of skeletal structure.
6. The development of heart and lungs as compared with the development of the alimentary tract, in relation to constitutional vigor and to capacity for early maturity.
7. Indications of relative development of muscle, fat and bone.
8. Breadth of chest—what determines it and what it signifies.
9. Relation of heart-girth to development of lungs.
10. Proportions of the skull and what they indicate.
11. Conditions of development of the vertebral column and what they indicate.
12. The anatomy, histology and physiology of the unsoundnesses of horses.
13. Conditions as to development and position of mammary veins and what they signify.

IV. THE ESTIMATION OF METABOLIC NITROGEN

As a temporary expedient, pending the completion of more nearly perfect feeding standards—a very important improvement of the Modified Wolff-Lehmann standards would result from reducing them to a basis of "refined digestible nutrients"—truly digestible crude protein (corrected for metabolic nitrogen) and truly digestible non-nitrogenous nutriment (corrected for fermentation losses in methane and carbon dioxide).

One of the prerequisites of this improvement is the determination of the amount of metabolic nitrogen in the feces. There is no known method for estimating metabolic nitrogen with anything approaching scientific accuracy, but we suggest a method of approach to this problem which seems to us worthy of consideration.

Choose several proteins, which, presumably, are completely digestible. In nitrogen balance experiments add each of these proteins, in graduated amounts, in a series of experimental periods, to otherwise nitrogen-free basal rations. That kind of protein which, when thus varied in amount, does not cause the total feces nitrogen to vary, we would rate as *completely digestible;* and the total feces nitrogen in these periods would be considered as of metabolic origin.

Having thus determined the amount of the metabolic nitrogen, then determine, by further experimentation, the relation of the metabolic nitrogen outgo to the live weight, or to the surface area of the animal, or to whatever other readily determinable factor it may be found to vary with, thus making possible the computation, by difference, of the indigestible and the truly digestible protein.

It is believed that this will give more nearly true figures for metabolic nitrogen than will those representing the total nitrogen of the feces from a nitrogen-free ration, since the presence of a normal proportion of protein in the ration will be conducive to the growth of a normal bacterial flora in the alimentary tract, these bacteria, presumably, contributing an important fraction to the indigestible protein of the feces.

V. MINERAL REQUIREMENTS OF FARM ANIMALS

An important problem in this field is to determine, by carefully controlled, long-time feeding experiments with dairy cattle, under conditions of practice, the effect of differences of intake of mineral nutrients, especially as contained in leguminous as compared with gramineous roughage, and in mineral supplements, on growth and productive efficiency.

In order to obtain reliable determinations of final effects the observations should be carried through the entire period of growth and production, with a considerable number of individuals.

VI. VITAMIN REQUIREMENTS OF FARM ANIMALS

The knowledge of the vitamins should be ex-

tended as far as possible into the field of animal production.

Poultry furnish excellent material for vitamin studies; swine are also conveniently usable; and there is some evidence that a vitamin in forage is intimately related to the utilization of mineral nutrients by ruminants.

The effects of feeds, and of methods of production of feeds, on the vitamin content of the milk and the tissues and organs of animals should also be investigated.

VII. DIET AND REPRODUCTION

Evidence is gradually accumulating which suggests that diet is a factor of greater importance than has been understood in relation to reproduction in farm animals. While it appears that mineral nutrients and vitamins may contribute to the specific effects of feeds, in this relation, we do not have evidence to indicate that these effects are due to these two factors alone.

Poultry, swine and cattle are conveniently usable for the investigation of this problem, and there are indications that the general system of farming, as determining the feeds available, contributes in important ways to efficiency of reproduction in livestock. So important a situation must challenge the researcher in the field of animal production.

IN CONCLUSION

The members of this sub-committee, individually, and the sub-committee, as such, have given especial attention to methods of experimentation in animal nutrition. The sub-committee offers its cooperation to any who may desire it, in the making of detailed plans for investigations in any of the fields suggested.

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THE CONFIRMATION OF THE EINSTEIN PREDICTION[1]

IN the year 1916 Professor Einstein extended his theory of relativity to include gravitation. Einstein expresses the law of gravitation in a form very different from Newton's inverse square of the distance. But in nearly all applications to the movements of the heavenly bodies the two laws give identical results. Had it not been so, the new theory could not have been right, for Newton's law is able to predict the movements of the sun, moon and planets with the utmost precision. But Einstein pointed out three refined observations in which his law differed from Newton's. The first of these is a small rotation of the orbit of the planet Mercury, discovered by Leverrier and, in spite of many attempts, was not satisfactorily explained. Einstein's law agreed with the observations and accounted for a small divergence from Newton's law. This remarkable achievement aroused the interest of astronomers in the new theory.

Einstein pointed out that not only matter, but also light was subject to gravitation. A ray of light which in its journey to the earth passes near the sun will have its path appreciably bent. If a photograph could be taken showing the stars surrounding the sun, these would be in slightly different relative positions from those they occupy in a photograph taken when the sun is in another part of the sky. Owing to the great light of the sun such a photograph can only be taken during a total solar eclipse. It was pointed out by Einstein that with Newton's law also the light passing near the sun would be deflected, but only to half the extent predicted by the generalized theory of relativity.

Two British expeditions went out in 1919 to observe the eclipse of May, Professor Eddington and Mr. Cottingham to Principe on the West Coast of Africa, and Dr. Crommelin and Mr. Davidson from Greenwich to North Brazil. There were three possibilities. Would the light be deflected at all, or by the amount Einstein's law required, or by half this amount? The observations are not easy, because the quantity to be observed is very small. A star on the photographic plate is a small dot, and the displacements to be expected only amounted to

[1] From the London *Times*.