PROTEINS AND REPRODUCTION

William A. Albrecht

Department of Soils
University of Missouri

The third of five papers presented
in a symposium on the general topic

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THE question that I am asked to discuss in this symposium is the probable relationship between the protein supply of a land or area and the birth rate of the people there. We are, of course, only at the beginning of knowledge in such matters; but from all that I have been able to gather in studying the intricate relationship between soils and the protein pattern I am not inclined to believe that high-protein diets, in themselves, diminish either fecundity or survival, and thereby lighten the population load on the land.

Other factors, economic and social, that customarily accompany the higher standards of living achieved by richer lands and peoples may lead, as Sir John Boyd-Orr, Dr. Josué de Castro and others indicate, to a lower birth rate; but a high intake of proteins seems to me, in the light of a whole chain of living evidence, to increase both fecundity and longevity.

Let us first get away from the myopic view that sees shortages of food only in the quantitative terms of calories, or shortages of "crude" proteins in terms of human need alone. Let us start in the soil and examine the evidence logically—and ecologically—from the ground up.

Protein shortages are intricately connected with the behavior of animals, plants, and microbes, all of which are successive parts in the biotic pyramid that has man as its apex, and the soil as the foundation of the whole structure.

The soil's pattern of fertility elements for various countries was possibly the determiner of man's migrations on the face of the earth. The soil's pattern may be more subtle, but it is more uncompromising than any politics, policies of colonizations, recommendations by Councils of United Nations, or other politico-sociological forces. For it is the soil that determines the proteins by which we get protection and by which we have *reproduction*.

The provision of proteins in any area does more to delineate the different life patterns than almost any other ecological factor. It is these protein compounds that alone can keep life flowing. They build the body tissue. In fact, only they represent growth as cell multiplication. This stricter interpretation of the term "growth" is quite different, of course, from considering it simply as the increase in body weight. Weight has been the common concept of growth applied to animals in the pasture and the feedlot, and naturally so, when the hanging on of fat and the loading of the tissues with water serve so well to make the practice of buying low and selling high a lucrative one.

But even then, the success of this speculative venture demands the exclusion of the animal's reproductive potential. The feedlot phase of agriculture restricts itself largely to fattening the castrated males. Significantly, this practice finds itself located mainly on soils where the native crops serving as fattening feed are so deficient in proteins—not only in totals but also in nutritional quality thereof—as to demand protein supplements imported from other more fertile soils, or from places where the plants can provide more complete proteins.

The fattening of our beef cattle in the eastern half of the United States (grown largely farther west), and the growing of pigs in that eastern part as animals mainly fat—may seem an arrangement in accord with natural economic controls, but it goes deeper. Underneath the control

by economic forces there is in reality the specific control by a deficiency, of proteins, going back to the soil. This deficiency is not necessarily one of totals of proteins, as we measure their amounts when we determine the element nitrogen considered as making up 16 percent of the "crude" proteins. This controlling deficiency is more often the shortage within the feed and food supply of some of the protein's constituent parts, namely, the amino acids. Eight or possibly ten of the amino acids are considered absolutely essential (and required regularly) for the survival of the experimental white rat—and inferentially for the human species.

Man and the animals must be given these amino acids. These creatures cannot create their proteins from the simpler chemical elements (except to limited extent by microbial helps in the intestinal tract). Only plants and microbes are equal to this accomplishment. These lower life forms struggle for their required proteins too. But they can grow and reproduce by means of a more limited list of the amino acids. Consequently, the mere growth of plants is no assurance of their serving as a feed which will guarantee growth of the animals consuming them.

We are coming slowly to realize that the array of the amino acids within the same plant species in uniform ratios is not the rule, except as the soil fertility contributes the required creative elements accordingly. In consequence, the animal may be able to cover enough territory, or to find enough of particular plants so as to provide itself with complete proteins. It is through the proteins in the main that the soil controls the many forms of terrestrial animal life. Even for the marine forms, the sea supports them mainly where the soil inwash and the shallow, well-lighted waters grow microscopic plants to feed proteins to the little fish so they in turn can be feed for the bigger ones.

The soil fertility pattern as it expresses itself in the pattern of protein potential is, then, a significant determiner in any ecology. This holds true even for the ecology of man, save as his technologies give him life lines to drag the required fertility to his more nearly local soil from distant ones, or periodically let him make excursions out far enough and often enough to satisfy his hidden hungers before they extinguish him.

II

THE areas favorable to man and the food animals supporting him are those where the soil processes under the particular climatic forces are breaking down the rocks and minerals to provide the flow of all the essential chemical elements to the plant roots. These must come in such amounts and ratios as will support those plants synthesizing the complete proteins. Such conditions prevail mainly in the temperature zones under moderate rainfalls, or the equivalents in the chemo-dynamics for providing the fertility within the soil.

High rainfalls, then, to wash nutrients out of the soil into the sea do not represent protein potential in the vegetation, though they represent voluminous production of carbohydrates in cellulose, starch, and sugars. Low rainfalls, too, fail to provide proteins, for they fail to build the rocks into a soil that will sufficiently provide plants with protein, even when water is provided for the crops.

The favorable place, then, for our protein-rich plants in the climate-soil-ecological pattern is on the moderately weathered soils. Those plants include not only the legumes, but also the protein-rich herbage that puts our protein-producing beef cattle (lean meat) and

sheep (lean meat and wool) on these same soils under range conditions. These animals will seek the same soils which in their virgin state made the brawn and bone of the buffalo, but supported no extensive animal-fattening industry. It is those same soils where today wheat makes more protein of itself to give us the "staff of life" when protected from the ultra-refining processes to make the "white" bread. Those are the soils considered under too little rainfall for big yields per acre, even if it was there where the cow went ahead of the plow while assaying them with favorable report for reproduction of herself and for like performances by man. As man pushes himself off these protein-producing soils on to the "fringe" soils, he must extend his life lines from the latter back to the former, except as he can tolerate increasnig degrees of malnutrition and partial starvation.

Now that we have overrun the earth by means of technologies, have exploited our soils by them, and have extended our life lines to the point of fishing the Antartic for proteins in whale meat, we are seeing those life lines shortened gradually if not already breaking and often severed. That shortages of proteins originate in our soils is as yet unrecognized. We are failing to see man in the larger picture.

We hold post-mortems and offer explanations but fail to comprehend causes. We run the motion picture film backwards, as it were, in our delusion that we control the ecology. Man, like other animals, is an expression of the natural forces ruling him far more than he can rule Nature. Thus is generated a blind faith that man can extend himself over the vast acreages of land unused, with no thought as to the reasons why they are so. History makes little of its record that man has already tried such areas with a resulting failure to maintain himself there.

Much land remains as acres but the serious shortages in the soil as source of complete proteins offers provocation for a revival of remarks once made by Malthus. There are qualitative deficiencies, and while many phases of man's behavior are subjects of debate, no one to date has come up to take the negative side of the proposition that "Man must eat, and particularly of the proteins."

III

OUR use of antibiotics is acceptance by us of the synthetic services for our protection by the lowly microbes. From next to the soil, at the bottom of the biotic pyramid, these chemical services approaching those represented in the synthesis of proteins are passed up to us at the top for our protection against other but dangerous microbes. Plants, too, offer protection in their many compounds simulating proteins, when they give us vitamins, hormones, via catalytic and stimulating effects still unknown. Proteins are still the major protection against disease and degeneration of the body.

It is in terms of specific proteins that our animals give us protection when we use the serums, vaccines, and various inoculants made from animal blood proteins. It is the cow that can take our disease of smallpox, can live through the scourge of it, can build proteins in her bloodstream to protect herself against recurrence of it, and then can share those proteins with us for the vaccination and protection of hundreds of humans. Yet she does that by support of no specific drugs, but by support of nutritional compounds no more startling than those in green grass growing on fertile soil.

The horse takes our form of typhoid fever. With apparently no serious disruption of his health, he creates proteins

to combat the effects of the typhoid bacteria, and shares those disease-fighting compounds as inoculative protection for human beings. Our bodies may often suffer from insufficient ability to corral and to create antibiotic, protein-like substances for protection against invasions by foreign, death-dealing microbial proteins. Yet with a little help from proteins brought to us by the microbes, the plants, and the animals, we carry or create sufficient of our proteins for protection.

Plants also protect themselves by means of proteins. Experimental trials have demonstrated that by increasing those fertility elements in the soil which were serving for increasing proteins in the young plants, there was provided increasing protection against the attack by a fungus suggesting one connected with the "damping off" disease. In another experiment, more nitrogen and more calcium offered to vegetable plants for higher concentrations of proteins in these food crops, gave more protection against attack on the plants by leaf-eating-insects. Here was suggested the possible converse of this demonstration, namely, that the increasing fungus diseases of our crops and the increasing insect attacks on them seem to be premised on deficiencies of protective proteins in the plants, and these in turn on the deficiencies of the fertility in the soil.

Shall we not, then, open our minds to the possibility that the shortages of proteins and shortages of all that is associated with them in their synthesis by microbes, by plants, and by animals, are prohibiting us through a kind of malnutrition from collecting and creating the necessary list of proteins by which our bodies can protect themselves, or build their own immunity?

Seemingly, our wild animals gather their own "medicines" by instinctive selections, not only among different plant species, but also amongst the plants of the same species according to differences in the fertility of the soils growing it. Our domestic animals manifest similar selections within the limits permitted by our enclosure of them within fences, barns, stanchions, and other hindrances to their exercise of choices for their own better nutrition and better protection against diseases. While proteins are the major nutritional "cure" for tuberculosis, we are still unmindful of the many other diseases against which complete proteins may possibly be a protection.

IV

IT WAS some experiments using sheep as farm animals and rabbits under more carefully controlled procedures which demonstrated the fact that the soils and proteins can control reproduction possibilities. Ewe lambs were fed on legume hays grown on a less productive soil given (a) no treatment, (b) phosphate, and (c) both lime and phosphate. Their growths as increases in body weights were in the proportion of 8, 14, and 18 pounds per animal for the above treatments, respectively, when equal amounts of hay per head per day were consumed. The wool from those lambs fed hay grown on the soils with the more complete treatment was the only one among the three lots which could be scoured and carded without the destruction of the fibers. More significant, however, than the failure to secrete this protein fiber of normal quality in the case of the two lots of lambs fed the hay given only phosphate, or no soil treatment, was their failure also in their possibilities for *reproduction*.

When at the age of eighteen months the three lots of lambs were put with the ram, these two failed to mate and failed to give a lamb crop while those fed previously on hays grown on soils given both lime and phosphate for soil fertility im-

provement gave a lamb crop as the result of mating with the same male.

As additional test of the possible causal connection between soils, proteins, and reproduction, the two hays grown on the soil treatments of phosphate only and both lime and phosphate were fed to two lots of male rabbits in use for artificial insemination. Their regular delivery of semen was measured carefully and studied critically, only to find (a) the delivered volume decreasing, (b) the concentration of spermatozoa falling, and (c) the percentage of live spermatozoa declining rapidly, for those rabbits fed the hay grown on the soil of which the fertility was improved by no more than only a phosphate treatment.

Such was not the case, however, for those rabbits feeding on the hays grown on the soil given both lime and phosphate. No significant irregularities in the production and delivery of the semen was manifested by this second lot.

When these differences between those two lots were especially wide, the males of the former lot were approaching sexual impotency so closely that they were indifferent to the presence of a female in oestrus. At the same time, those in the latter lot manifested their interest in her the moment she was brought near their hutches.

Still more significant, as evidence of the relation of soils and crop proteins to reproduction, were the marked changes in reproductive potentials resulting when the feeding program was modified by merely interchanging the hays for the lots of rabbits. Only three weeks had elapsed after this shift in feeding, when the lot of originally impotent and indifferent animals was restored to sexual vigor with all the characteristics of potent males. The formerly potent ones exhibited falling curves for all the measurements. In the same short period of three weeks those on the hay grown with the limited soil treatment, had fallen to the same low level of the other lot before the hays were interchanged.

When, in these tests, the soil treatments for improved production of protein by legumes, as measured in terms of increased nitrogen in their hays, were the only variables responsible for shifting the sexual vigor from impotence to potence and vice versa, one can scarcely refute the causal connection between soils, proteins, protection, and reproduction. It appears as if the proteins as food compounds are connecting the animal, (a) in its survival as an individual via nutrition and protection against disease, and (b) in its survival as a species via fecund reproduction, very definitely with the combinations of the essential nutrient elements in the soil.

V

WHEN plants get their proteins in varying degrees of completeness for their reproduction via seed according as the more complete suites of fertility elements in the soil permit; when herbivorous animals must depend on the plants for their proteins as a collection of all the required amino acids; when protection against invasion of our own bodies by death-dealing agencies is given us by proteins; and when the stream of reproduction of any life can be kept flowing only by means of proteins, shall we envision man as capable of sidestepping this pattern of controls? Would it not be more logical to build our conceptual scheme of his behaviors as merely that of another animal more complex in its physiological requirements, of less privilege for variance from these controls, and subject to greater potential disaster if he disregards these controls?

Man's extension of his kind over the earth as a nomad following his herds was according to the protein-producing capacities delineated by the reliable ani-

mal instincts. But man's extension of his kind under his own technologies pushed him away from the fertile soils that were guaranteeing proteins, protection, and reproduction of himself and his species. It pushed him on to the "fringe" soils in these respects, but at the hazard and necessity of using his technologies to reach back to, and keep connected with, those same fertile soils (or the sea) his life lines bringing him the protein foods and all that comes with them for supplementing his hazardous location. Those life lines may soon become tangled with lines of economics and politics. They may be shortened or cut off and such fringe soils supporting only mono-cultures of crops then demonstrate man's nutritional insecurity. They generate hungers apt to be interpreted in most any other way except that they are the result of a protein shortage going back to fertility shortages in the soil. Man is a social animal when well fed, but if put under starvation he even becomes cannibalistic, or gets his proteins at the price of murder.

When the pre-death struggle of the protein-starved man to save himself as an individual rises to the desperate height of cannibalism, is this not akin to the immediate pre-death struggle of the processes of our bodies manifested by increased rate of heart beat, increased blood pressure, and temperature rise as fever? If then a segment of the human species under protein-starvation makes a desperate survival effort in the form of increased reproduction when other efforts for that have appeared in vain, would this not seem to aggravate the hazards for survival all the more? Would not such a manifestation seem of more logical interpretation when considered mainly as the pre-death struggle by the species?

Naturally, there are possibilities for wide variances between our individual conceptual schemes for man's behavior under severe hunger. But when in his fundamental physiologies man is viewed as another animal, he can scarcely set himself outside of the natural forces which seem so completely in control. If the complete proteins determine body protection and reproduction of our animals; if the life forms just below man depend on plants for these essential foods still non-synthesizable by either science or industry, and if plant proteins are determined by the soil, then the soil fertility as it controls the animals in their reproductive potential would seem to be also the logical power in control of man's reproduction too.