Operating Procedures of the Zoological Division 1943

The Zoological Division has as its objective the carrying out of basic investigations on the parasites and parasitic diseases of livestock and poultry. The results of these investigations are translated into practical procedures and tested out in the field under small scale conditions. If found satisfactory, these procedures are recommended for general use by the stockman or farmer or for further testing under large scale field conditions.

The Zoological Division's field station at the Beltsville Research Center was established for the study of internal parasites of livestock and poultry. The work at this station involves the study of various protozoan and worm parasites, their life cycles, and methods for their control. Important among these investigations ~~is~~ are the development and standardization of drugs having parasiticidal properties which may be used either alone or in combination with husbandry procedures to effect control or eradication of the various important parasites.

The work at Beltsville is carried out under 12 work projects, as follows:

1. Investigations of anaplasmosis of cattle. Anaplasmosis is an important blood disease of cattle caused by a parasite, the exact nature of which is not clearly understood. The work under this project is directed toward the determination of the nature of the parasite, its mode of transmission, and measures for its control. At the present time special emphasis is placed upon finding a satisfactory treatment for the disease.

Personnel: One assistant protozoologist (P-2) and one scientific aide (SP-5) part time. The work is supervised by a protozoologist (P-4) who also supervises the work of other projects dealing with protozoan parasites.

2. Investigations of bovine trichomoniasis. Bovine trichomoniasis is a disease of breeding cattle. It is transmitted by infected bulls to cows and results in failure to conceive, early abortion, and sterility. The work so far has resulted in the finding of improved methods of diagnosis. Experiments to

determine a satisfactory treatment of infected bulls is the principal activity at present.

Personnel: Until recently the project was staffed by an assistant protozoologist (P-2) and a junior veterinarian (P-1). There now exists a vacancy in the P-2 position, the work being carried out by the junior veterinarian under the supervision of a protozoologist (P-4) who also supervises other projects dealing with protozoan parasites.

3. Investigations of coccidiosis of sheep, goats, and swine. The work of this project involves the determination of the injurious effects of the various species of coccidia under farm, range, and feed lot conditions and of experiments to discover satisfactory control measures for these species.

Personnel: One protozoologist (P-4) in charge, who also supervises the projects on anaplasmosis and bovine trichomoniasis, and one scientific aide (SP-5) part time.

4. Investigations of coccidiosis and other protozoan diseases of poultry. Under this project are conducted investigations of coccidiosis, which is one of the most destructive diseases of chickens, and of trichomoniasis and blackhead of turkeys. Special attention is being paid to the development of satisfactory control measures for these important diseases.

Personnel: One zoologist (P-4) in charge, who is also in charge of the project, Worm parasites of poultry, an associate protozoologist (P-3), and an assistant parasitologist (P-2).

5. Investigations of worm parasites of horses. The work of this project at present is directed toward the control of strongyles or bloodworms, which are largely responsible for unthriftiness, intermittent lameness, and colics.

Personnel: One associate parasitologist (P-3).

6. Investigations of worm parasites of sheep and goats. Under this project are conducted investigations on the injurious effects and methods of control

of the various worm parasites of sheep and goats, such as the nodular worm, which, in addition to producing unthriftiness and consequent failure to make adequate gains, causes injury to the intestines and renders them unfit for use as sausage casings and for the manufacture of surgical sutures. Special emphasis is placed on determining the survival or failureto survive on pasture of the larval stages of the various parasites to determine the length of time necessary for pastures to lie idle to insure that animals that have been rendered worm-free by medicinal treatment will not acquire during a grazing season a sufficient number of worms to produce perceptible losses.

Personnel: One parasitologist (P-4) in charge, one zoologist (P-2), one parasitologist (P-2), and one junior zoologist (P-1).

7. Investigations of worm parasites of swine. The purpose of this project is to investigate such parasites of swine as the common roundworm, stomach worms, kidney worms, nodular worms, lungworms, trichinae, and any other helminth parasite that may influence deleteriously the health of swine or which may be transmissible to man.

Personnel: One zoologist (P-4) in charge and one scientific aide (SP-5) part time, one junior parasitologist (P-1) at Beltsville, and one associate parasitologist (P-3) at Tifton, Georgia.

8. Investigations of the worm parasites of poultry. In this project investigations are carried out on the various threadworms, roundworms, and tapeworms of chickens, turkeys, and related birds. Special attention is given to the control of the cecal worm of chickens and turkeys which transmits to turkeys a very destructive disease known as blackhead, and to the minute threadworms of the crop and other parts of the digestive tract.

Personnel: One zoologist (P-4) in charge, one assistant parasitologist (P-2) part time, one junior parasitologist (P-1), and one junior zoologist (P-1).

9. Investigations of parasites of food animals of importance in meat inspection. Under this project investigations are conducted on the effects of various refrigeration, curing, and processing practises on parasites such as trichinae and tapeworms that are communicable to man. Information obtained from these investigations is used as a basis of regulations governing the above-named practises.

Personnel: One zoologist (P-4) part time, one scientific aide (SP-5) part time at Beltsville, and one associate parasitologist (P-3) full time at Chicago.

10. Investigations of parasites of dogs, wild animals, and birds transmissible to livestock. Under ordinary circumstances this project conducts investigations on the parasites of dogs and wild animals to determine what parasites they harbor that may be communicable to livestock and poultry. This project also serves as a taxonomic unit, making identifications for various governmental and other institutions of ticks, fleas, lice, and worm parasites. Since the entry of the United States into the war, this service work has been largely discontinued and special problems have been undertaken in collaboration with the project, Worm parasites of sheep and goats.

Personnel: One senior parasitologist (P-5) (Assistant Chief of Division) in charge, one zoologist (P-4), one associate zoologist (P-3), one scientific illustrator (SP-5), and one scientific aide (SP-5). The last two employees also serve all other projects.

11. Index-catalogue of medical and veterinary zoology and maintenance of collections: The index-catalogue consists of a cross index to the literature on parasitological subjects and is arranged according to authors, subjects, and hosts. This project is mainly a service one and makes available references to the literature on the various subjects with which the scientific staff is concerned. Many man years of time are saved through the medium of this service. Since our entry into the war, this catalogue has been an invaluable source of

information on the parasites of man and domestic animals occurring in different parts of the world in which our troops are stationed.

The parasite collection consists of types and other specimens of parasites and is one of the largest in the world. It is constantly used as a source of information on the distribution of important parasites of livestock and other animals.

Personnel: One assistant librarian (P-2) in charge, one junior parasitologist (P-1), one scientific aide (SP-5), and one library assistant (SP-5).

12. Investigations for the development of treatments for the removal of internal parasites. The object of this project is to develop and standardize treatments for the removal of internal parasites to find substitutes for existing medicaments that are now scarce or unavailable and to develop treatments for the parasites for which no satisfactory medication exists at present.

Personnel: One associate parasitologist (P-3) in charge, one assistant veterinarian (P-2), one junior zoologist (P-1), and one junior veterinarian (P-1).

Administration

The administration of the station, including the care and up-keep of buildings, experimental animals, equipment and supplies, and finances is under the supervision of a superintendent, in collaboration with the Assistant Chief of the Division.

Personnel: One associate veterinarian (P-3) superintendent, one senior clerk (CAF-5), one assistant clerk stenographer (CAF-3), one assistant clerk typist (CAF-3), one under clerk(CAF-1), one agricultural aide (SP-5) farm foreman, one junior agricultural aide (SP-3) assistant farm foreman, one junior agricultural aide (SP-3), ten under agricultural aides (SP-2), one junior laborer (CPC-2), and one junior field station helper (CPC-2). There are in addition two watchmen and one janitor supplied by the Beltsville Research Center.

The duties of the agricultural aide group are to care for the animals, buildings, pastures, and other facilities used by the scientific personnel in the conduct of their research problems.

Recapitulation of Personnel

There are at present 49 employees at the Beltsville station, consisting of 23 professional employees, 6 scientific aides, 13 agricultural aides, 5 clerical and administrative employees, and 2 charwomen. In addition to these 49 employees, there are two vacancies, one assistant protozoologist (P-2) and one junior parasitologist (P-1).

Procedure

In the scientific work of the station, the procedures followed are those of a standard sort that have been found to give the required results with the minimum of equipment and personnel. The administrative work involves the keeping of records, purchasing of equipment, feed, and other supplies, preparing time reports in accordance with the regulations of the Bureau and Department. So far as possible these procedures have been simplified in the interest of economy. The farm practises involve the care and upkeep of buildings, feeding and caring for experimental animals, clearing, seeding, and maintenance of pastures. In addition, the labor force (agricultural aides) assist the scientific staff in restraining animals and similar work.

Conclusions

The work of the Zoological Division is in direct line with the Department's objective to increase production of livestock and poultry, its functions being directed toward the prevention of losses and making for better livestock and poultry through the medium of control measures designed to prevent animals and poultry from becoming infected with parasites that interfere with normal gains. In view of the fact that the Department recognizes that internal parasites

cause losses to the livestock industry equal to those caused by all infectious diseases combined (Yearbook of Agriculture, 1942), it appears that the present personnel of the Zoological Division is inadequate to meet its obligations under wartime conditions. Therefore, it is our honest belief that no reduction in personnel can be effected without a curtailment of essential activities which would result in a failure to meet our recognized obligations during this period of national emergency.

PROTOZOOLOGICAL INVESTIGATIONS

of

ANIMAL DISEASE AND PARASITE RESEARCH DIVISION

Background Statement

Protozoan diseases are caused by parasitic organisms that are only slightly larger than bacteria. The bodies of Protozoa are composed of a single cell. All the essential functions of life are performed within the compass of this cell. Some protozoan parasites are equipped with locomotor organs. Others are not. Some live in the digestive tract and cause disorders thereof. They are generally spread through the medium of feed and water contaminated with droppings of affected animals. Others, transmitted by breeding, invade and damage the reproductive system and the foetus and thereby interfere with reproduction. Others, transmitted by insects, live in the blood stream, bone marrow, liver, glands, and elsewhere. They produce, anemia, fever, and disorders of other types. Each species of animal and bird generally is plagued by its own types of protozoan disorders. Some of these disorders, however, may affect more than one type of animal or poultry.

Recognition of protozoan organisms as causes of livestock and poultry diseases has been slow in developing. For many years disease work in the Department of Agriculture was directed mainly at disorders caused by bacteria, viruses and worms. With a few exceptions, it is only recently that the importance of protozoan diseases has been fully recognized and attention directed to them. In this respect, protozoology of livestock has lagged behind protozoology of human beings. Livestock and poultry are plagued by a greater

variety of protozoan diseases than are human beings. Some of those affecting livestock are as injurious, or even more so than are malaria and amebiasis of humans. Due to the hygienic habits of livestock and poultry, their protozoan diseases are even more difficult to control and treat than are similar disorders of human beings. Some of the protozoan diseases of livestock and poultry exhibit a less "explosive" course than related diseases of humans, being of a more or less chronic nature. For this and other reasons, protozoan diseases of livestock generally attract less attention than those afflicting people.

Very fortunately some of the most devastating protozoan diseases of livestock do not at this time occur in the United States. Some of them occur in Central and South America, as well as in other countries. These diseases are largely caused by parasites that invade the blood stream, and are transmitted by insects. The various forms of trypanosomiasis, East Coast Fever, Leishmaniasis are examples. Were these diseases to gain a foothold into the highly susceptible livestock population of this country, the results could be disastrous. At the present time, United States is not fully equipped to deal with and eradicate these diseases should they appear in this country.

(A) Nature of Work

2. Purpose and Objectives - By control and eradication of protozoan diseases, provide for healthy livestock and poultry, which is necessary for a progressive, prosperous agriculture. This is a basis for a sound national economy, a high standard of living and a healthy population. Diseases caused by protozoan organisms, like other diseases, affect all segments of the agricultural economy in which livestock, poultry and their products are involved. They levy a severe toll on the health of man's animals and birds. They are many times a determining factor in production. Healthy animals increase food-conservation efficiency. This results in profitable utilization of tillable and pasture lands. Healthy animals and birds provide better and more palatable food for man than those made unthrifty by protozoan diseases, and thereby contribute to the health of the human population.

(A) Nature of Work

3. Current Work - Current work is aimed at implementing the purposes and objectives outlined above (see 2). It involves a long-range program of basic and applied research. This work is being carried on within limitations imposed by availability of personnel, equipment and funds. It is arranged according to hosts, or type, of animal. Protozoan diseases occurring naturally in these hosts as well as those transmissible to them from wildlife are investigated. The overall problem involves a wide variety of broad and complex subjects, a few of which are listed below.

a. Ecology of organisms. (The effect of environmental factors on the organisms and the response of these organisms to the factors involved.)

b. Epidemiology of diseases (Source, contributing factors, and immediate causes of outbreaks).

c. Characterization of organisms and diseases caused by them.

d. Culture characteristics of the organisms (means of growing them outside the host for use in research to develop an understanding of the diseases, development of vaccines and other immunizing agents for combatting diseases).

e. Life cycles, including development of the organisms within the host.

f. Pathology. (The nature of disease, the development of morbid processes and functional and structural changes resulting therefrom.)

g. Pathognomy (Signs and symptoms of disease).

h. Diagnosis (Development of methods for -).

i. Resistance and Immunity (Elucidation of, and development of measures for establishing immunity and resistance by artificial means).

j. Realignment of agricultural practices to diseases for purposes of prevention and control.

k. Control of diseases by management, breeding immunization, alteration of environments of animals and by other means.

l. Economics, practicability and application of control programs.

Only small segments of any of the overall programs listed above can be attacked at one time due to serious limitations and restrictions as regards availability of personnel, equipment and funds. Protozoan diseases currently being studied by the Department of Agriculture and the location of the work are listed below.

Genital Trichomoniasis of Cattle - Utah

Coccidiosis of Cattle - Utah; Montana; Alabama

Coccidiosis of Sheep - Alabama; Utah; Beltsville, Maryland

Coccidiosis of Poultry - Beltsville, Maryland

Blackhead of Poultry - Beltsville, Maryland

Coccidiosis and Related Protozoan Disorders of Swine - Alabama

(B) Accomplishments and Their Significance

Trichomoniasis of cattle. The serious venereal disease of cattle known as trichomoniasis (caused by the one-celled organism Trichomonas foetus occurring in the reproductive organs) was found to be present in cattle of the United States in 1932. Investigations of this disease were begun by the Department in 1936, to develop means of protecting cattle owners from losses in their herds through abortion, sterility, and breeding difficulties caused by the disease. In the course of these investigations the problems of diagnosis, spread of the infection within and among herds, the duration of the infection and the management of infected herds were studied. When it was discovered that the disease is introduced into clean, uninfected herds only by the introduction of an infected animal, and spreads within herds only by natural breeding operations, lines of study were suggested for management practices as control measures. Also, the discovery that infected males usually retain and transmit the disease almost indefinitely led to work on development of an effective treatment for infected bulls. As a result of the investigational work, a management and breeding program was devised for infected herds that will eliminate the infection. Also, a determination was made of the nature of the disease and the course and duration of the infection. This formed the basis for determining the animals to be examined for diagnosis. Thus, the problem of diagnosis was made easier and the diagnosis itself more accurate and certain. This discovery has saved a tremendous amount of time and labor in combatting the disease. Applying the results of work already done, progress has been made in combatting trichomoniasis of cattle on certain ranges in the

West where the disease had become established at some undetermined time in the past and has been causing losses estimated at more than $800 per infected bull annually. Progress in controlling this reproductive disorder of dairy and beef cattle would result in increased numbers of these animals on farms and ranches, and increased supplies of meat, milk and its products.

Coccidiosis of cattle. This work was begun in 1938 because coccidiosis was considered to be one of the three most important diseases affecting calves in the Southeast. The first investigation was made to determine the number of species of coccidia that occurred in cattle on farms. As little was known about the transmission of the disease and the comparative destructiveness of the 10 species found, these were then studied further. Field surveys showed the presence of coccidia on nearly every farm examined, and they were found to be causing more unthriftiness and deaths among the animals than was generally believed to be the case. The next step was a study of the life histories of the most important species to determine the best time to attempt to break the life cycles of the parasites. In studies of treatments, three sulfa drugs were tested. Under certain conditions, administration of these drugs was beneficial. At the same time, it was recognized that calf management methods might prevent self- and cross-contamination and reduce the necessity for drug treatment. Consequently, various systems of calf raising were investigated and resulted in development of a system of raising calves free of coccidiosis and other diseases that has prevented deaths of countless calves and effected savings of many thousands of dollars, annually. In fact, before development of this system, now widely used in some foreign countries,

production of calves in certain areas of the United States was almost at a standstill. Coccidiosis of a somewhat different type, known as Winter Coccidiosis, occurs in the West. Calves break with bloody scours about three weeks after the onset of cold weather in the fall. Treatments with sulfa drugs have proven promising. Sources of infection have not been discovered.

Tick Fever. An important accomplishment in the field of protozoan parasitology is the discovery of facts concerning the nature of the causative agent of this disease, and its method of transmission. This was the first demonstration of insect transmission of a protozoan disease. It opened the way to the discovery of mosquito transmission of malaria, a worldwide problem. Control of Tick Fever made possible improvements in cattle production and facilitated interchange of cattle throughout the United States and Canada.

Protozoan Diseases of Poultry. Diseases caused by protozoan parasites have long caused serious losses to poultry producers. In the country as a whole, producers are probably better acquainted with coccidiosis and blackhead than any other diseases of poultry. About two decades ago coccidiosis was believed to be caused by a single species. Now two forms, each caused by one or more species of organism are recognized. Eight species of coccidia, all differing in their biology, injuriousness, and resistance to natural factors have been identified in the chicken alone. As work on the life histories of coccidia progressed, knowledge of these parasites and the diseases they cause has made possible improvements in methods of control. Growers of poultry have found that by raising birds on wire and away from direct contact with soil and excreta, blackhead, coccidiosis and other protozoan diseases

can be better controlled. Many poultry raisers are using large tracts of land and are rotating their birds so that the same land will be occupied not oftener than at least 2 years. Small poultrymen with limited means cannot follow such systems. Therefore, other methods of controlling protozoan diseases of poultry must be discovered.

Until the late 1920s or early 1930s turkey raising was on a very small scale in this country largely because of the prevalence and destructiveness of blackhead. As a result of research, parasite control measures have been developed and turkey raising has expanded in areas where previously the disease had forced the industry to be abandoned.

Work in the Department of Agriculture confirmed and established the idea that the number of coccidia swallowed by a bird bears a definite relationship to the development of coccidiosis. If it were certain that the birds would swallow only a small number of oocysts there would be no reason for advising thorough and frequent cleaning as a means of controlling coccidiosis. Under such conditions, the birds would develop only a slight or mild form of the disease and become immunized. It was found that it is only when the birds ingest large numbers of oocysts that control becomes necessary. It was found that coccidiosis runs a limited course. Tests showed that most fowl completely expel the coccidia parasites in the droppings within approximately a month after infection. This discovery, not only establishes the period during which a bird may remain infected, but furnishes information on which to base control measures. It was also demonstrated that birds surviving an attack of coccidiosis are highly resistant to subsequent infections. It was further observed that some commercially raised fowl may develop coccidiosis after maturity, but most of

these birds are known to possess a high degree of resistance to experimental inoculation. This resistance is not due to age, as was formerly believed, but a result of continuous swallowing of small numbers of coccidia. Research showed that once birds became immunized to a particular type of coccidiosis, they remain refractory to the disease. This has formed the basis for a thriving industry in the production of vaccines against coccidiosis of chickens.

A further outgrowth of the research is the finding that most species of coccidia are host-specific. The species of coccidia parasitizing one variety of bird are seldom transmissible to another. This discovery has proved of importance in determining the limits of infection and suggests methods for control.

Poultry coccidia survive on soil for a long period of time. In work in the Department it was found that all species of poultry coccidia survived continuous exposure to outside weather conditions for 10 months to 2½ years. This discovery led to the widespread practice of allowing coccidia-contaminated land to rest for 1 to 2 years before restocking.

The discovery that sulfanilamide hinders the normal development of several species of coccidia in poultry furnished a clue for the testing of other drugs of similar composition. Others of the sulfa group were found to be even more effective than the ones named. This information has been used and is being applied the world over.

The significance of the foregoing accomplishments is that each contributes toward the development of an understanding of protozoan diseases and constitutes

a step toward eradication. Any step toward control of a disease constitutes a part of an overall contribution to the development of a stable, prosperous agriculture. The accomplishments aforementioned have contributed toward development of the livestock and poultry industry and consequently toward the providing of cheaper, better, animal foods for the population. In these accomplishments, Department scientists have attained a position of worldwide leadership in work on the control of animal diseases. Knowledge brought to light by these workers is used worldwide, and has pointed the way to control of many protozoan diseases of livestock in foreign countries. The worldwide stature of U. S. scientists has been increased thereby.

(C) Major Problem Areas - Eradication of protozoan diseases, along with diseases due to other causes, of livestock and poultry will contribute to a complete realization of the overall objectives. This constitutes the major problem, and the final goal is a solution of this problem. To accomplish this, a vast amount of work must be done in all of the fields listed in 3 above. To the extent that this is accomplished the welfare of man will be bettered, foreign relations improved thereby, and prestige of U. S. scientists enhanced, provided these scientists can take and maintain the lead in work leading to, and in eradication of diseases. Other barriers that must be overcome include a lack of understanding of the importance of protozoan diseases by stockmen and others, reluctance to cooperate in the application and testing of control measures on a practical scale, and the development of adequate techniques for combatting diseases. A recognition of the need for adequate financing of the work is of utmost importance. Without adequate financial support, workers of the caliber needed cannot be attracted and maintained, and world leadership in the work cannot be attained and sustained.

(D) Opportunities - Specific opportunities in the fields of the various protozoan diseases of livestock and poultry may be listed as follows.

Trichomoniasis of cattle. Improved methods of diagnosing this disease are sorely needed and constitute a baffling problem. Various methods of diagnosis have been suggested by investigators in this field without adequate proof of their value. Research is needed on diagnosis and control to prevent the possibility of cattle raisers wasting time and effort on worthless methods of controlling this serious disease.

Coccidiosis of cattle. Further study of life cycles of the parasites causing coccidiosis--To combat these parasites successfully, it is necessary to know where and how long each stage exists in the animal's body. It is important to know which of the 10 species are similar and which ones deviate from the usual cycle. This information is necessary to determine the weak links in the cycles--those that can be most easily destroyed--and thus aid in developing methods of prevention and control.

Further testing of drugs for treating calves suffering from coccidiosis--The ideal method of preventing and controlling coccidiosis would be an inexpensive harmless drug that could be given at certain intervals to reduce the amount of injury, but that would still enable the calf to produce an immunity to the disease. New drugs are being developed each year. Some of these may prove to be very destructive to the parasite without causing damage to the host's tissues, and tests should be made to determine their value. Moreover, many drugs have been recommended for treating this disease after inadequate tests. These unscientific reports have caused veterinarians

and farmers needless waste in time and money in using ineffective treatments. There is a great need for adequate experiments with various drugs to prove their value in the control of coccidiosis.

Methods of calf management for preventing coccidiosis and other diseases--It would be highly desirable to continue research on improved management practices that would be even more effective and less cumbersome than those already developed.

Coccidiosis of poultry. Determination of the exact cause of death resulting from cecal coccidiosis--Parasitic growths within the cells are responsible for the bursting of blood vessels, thus allowing the blood to escape. However, it is not known why many severely affected birds live, whereas others, less affected so far as the eye can detect, die. Both types of birds have been examined post mortem and the amount of blood in the ceca seemed unrelated to the severity of infection.

Studies on life history of turkey coccidia and injury caused by them --Turkeys are infected with two and perhaps three species of coccidia. Numerous reports from several localities have stated that losses in turkeys have occurred from coccidiosis. Consequently, life histories of the parasites would serve as foundations on which to develop valuable control measures.

Blackhead of poultry. Practical methods for inoculating turkeys with blackhead disease for experimental purposes--In attempts to inoculate test birds experimentally with cultured material the percentages of "takes" have been very low. In order to continue practical research on control methods for this highly fatal poultry disease, a successful method for experimental inoculation would be invaluable.

In the field of protozoan parasitology as a whole, there exist opportunities for significant contributions to livestock, and human welfare, through basic and applied research in specific fields listed below.

I. Diagnosis.

a. Isolation, characterization and classification of causative agents of disease.

b. Serologic tests to identify a specific response of the animal's body to specific agents.

c. Prevalence and distribution of disease agents the world over.

d. Allergic responses to identify animals exposed to infectious agents.

e. Histopathologic evaluation of affected tissues revealing changes that are indicative or confirmatory of specific diseases.

f. Patterns of clinical symptoms.

II. Immunology, tolerance.

a. Immunizing agents, to the degree of lowering incidence, but singly not effective in eradication.

b. Prophylactic and therapeutic values of antibiotics, endocrine derivatives.

c. Processing methods for destruction of parasites in edible parts and foodstuff preparations of animal carcasses on soil of pastures and in premises.

III. Mechanism of infection.

a. Investigations of causative agents, their incubation periods, courses of infection, clinical manifestations, methods of transmission and reservoirs of infection.

b. Mechanism of infection, mode of transmission and other aspects of life histories.

c. Bionomics of free-living stages, and of intermediate hosts.

In addition -

1. Chronological histopathologic studies of disease processes under controlled experimental conditions.

2. Growth requirements of organisms.

3. Biological control methods.

4. Pathogenesis of specific infections.

5. Mechanism of disease.

6. Economics of control programs.

7. Relation of nutrition and general well being to susceptibility.

8. Environmental control of infectious agents and of diseases caused by them.

9. Chemistry of infectious agents and its relationship to their ability to invade and infest body tissues and cells.

10. Chemical changes of body tissues and fluids in disease processes and in immunological responses.

11. Chemical and other fractionation of infectious agents and antibodies to develop more specific diagnostic tools.

12. Wild mammals and birds as reservoirs of disease agents.

13. Standards for diagnostic procedures as well as tools to cover new disease conditions as they arise.

14. Preservation of microorganisms, body tissues and fluids for long range studies.

The principal reasons for inadequacy of research on protozoan diseases are insufficient funds, personnel and facilities. It has been, and is, impossible to obtain and retain enough qualified research workers because salaries have not been, and are not, commensurate with those paid at other institutions for equal and similar responsibilities. Moreover, the numbers of large animals for statistically sound research have not been available because of lack of funds and facilities.

1962

Accomplishments of Protozoological Investigations

The following are considered to be some of the more significant of the historical incidents in the Department's work on diseases caused by protozoan parasites:

1886. Discovery that dourine, a reproductive disorder, caused by a protozoan parasite, a trypanosome, Trypanosoma equiperdum, had become established in horses in the United States. This discovery and subsequent work resulted in development of a diagnostic test and subsequent control of this disease.

1891. Elucidation of the essential steps in the life cycle of the cattle fever tick, in studies of tick fever. This work and subsequent studies based thereon served as the basis for determining frequency of dipping necessary to eradicate ticks that transmit so-called tick fever of cattle.

1895. Discovery that the causative agent of tick fever of cattle is a protozoan parasite of red blood cells.

1895. Elucidation of the nature of the disease, blackhead, of turkeys, and the discovery that the causative agent is a protozoan parasite.

1906. Determination that chickens can carry blackhead organisms without serious damage to themselves, but serve as sources of serious infections of turkeys.

1906. Discovery and extirpation of surra from shipment of Zebu cattle from India to the United States, which otherwise could have produced serious consequences.

1909. A Trypanosome, described from the blood of American cattle. Formerly it was thought that trypanosomes of cattle occurred only in cattle of certain foreign countries.

1912. Studies on the protozoan parasites of domestic animals published. This was the first comprehensive survey of the occurrence of these disease producing agents in American livestock. It formed the real basis for future work on protozoan diseases.

1916. Publication of a Report on stages of Piroplasma bigeminum, the cause of tick fever of cattle, occurring in ticks and their eggs.

1919. Discovery and extirpation of trypanosomiasis in Army horses returning from overseas.

1919. Discovery and extirpation of trypanosomiasis in shipment of camels being brought into the United States.

1931. Discovery that diets high in Vitamins A and B aid in control of poultry coccidiosis by increasing resistance.

1936. Fatal disease of domestic ducks in United States determined to be coccidiosis.

1937. Development of a microisolation technique for use in separating protozoan organisms from bacteria. This development made possible researches of a type not possible before this time.

1937. Reproductive tract trichomonads of cattle found to be transmitted by artificial insemination procedures.

1938. Means of differentiating species of coccidia of sheep devised, and discovery of new species of this parasite in sheep, bringing the total number to ten.

1940. Determination of sources from which sheep acquire coccidiosis.

1941. Discovery that sulphur in feeds controls coccidiosis in feeder lambs.

1941. Finding that poultry coccidia survive in the soil for long periods.

1941. Demonstration that chickens surviving an attack of coccidiosis are highly resistant to this disease.

1941. A foreign blood disease, Eperythrozoonosis, of cattle discovered in the United States.

1941. New species of coccidia of cattle described, bringing the total number known in this country to ten.

1942. Bartonellosis, a foreign blood disorder of cattle, discovered in American bovines.

1942-1943. Discovery that chickens subjected to repeated infections of coccidiosis could be immunized against subsequent fatal infections by administration of sulfa drugs in feed.

1945. Discovery that sarcosporidiosis of swine and other animals is a fungus disease.

1947. Determination of the nature of bovine genital trichomoniasis and the course and duration of the infection.

1947. Elucidation of the manner by which the drug, sulfamethazine, controls cecal coccidiosis of chickens, when administered in feed.

1946-1948. Development of a method of control of bovine venereal trichomoniasis through hygienic breeding.

1948. Control of cecal worms reduces blackhead in turkeys.

1949. Development of portable pen system of raising calves free of diseases and parasites.

1949. Demonstration that the severity of coccidiosis in equally susceptible fowls depends chiefly on the number of coccidia swallowed.

1949. Determination that most species of coccidia are host specific.

1949. Discovery that transmitting stages of species of coccidia of chickens require different developmental periods on soil. This finding made possible development of management schemes for the control of coccidiosis by rotation of runs.

1950. Demonstration that the transmitting stage of poultry coccidiosis is highly resistant to disinfectants.

1950. Discovery that coccidiosis runs a limited course.

1952. Discovery that leucocytozoan disease of turkeys is transmitted by blackflies.

1954. Elucidation of the life cycles and pathogenicity of species of coccidia of sheep.

1954. Evaluation of economic losses to livestock and poultry industry caused by protozoan disorders.

1955. Efficacy of Complement-Fixation Test for diagnosis of anaplasmosis evaluated and reported, leading to adoption of C. F. method as the official test for anaplasmosis.

1955-1957. Determination of the pathogenicity of several species of coccidia of cattle and description of their development within cattle.

1955-1958. Discovery that trichomonad flagellates of the nasal passages of swine are transmissible to the bovine reproductive tract, and that these infections can be a cause of reproductive difficulties in cattle.

1956. Demonstration that coccidiosis is a harmful disease of turkeys.

1957. Discovery of Babesia (parasites similar to those that cause tick fever of cattle) in deer in New Mexico--first recorded case in deer in United States.

1957. The discovery of Trypanosoma theileri, an American trypanosome of cattle, associated with and a potential cause of abortion by invasion of foetus.

1957-1958. Discovery of nonpathogenic strains of the blackhead organism, opening the way to development of a means of controlling this disease by immunization.

1958. Discovery that the addition of antibiotics to feed of chickens can enhance the action of certain coccidiostatic drugs in the control of cecal coccidiosis.

1958. Discovery of venereal trichomoniasis in western range cattle.

1958. Discovery of the causative agent of Chagas' disease, a trypanosome in wildlife in Maryland, and the demonstration that farm animals are susceptible. Chagas disease is an important disease of human beings in South America.

1959. Coccidiosis of sheep found to exert an adverse effect on the development and quality of wool of sheep.

1959. Discovery that blackhead organisms can remain alive on soil for at least four years.

1960. Field evaluation of Complement-Fixation Test for Anaplasmosis.

1960. Discovery of method for determining viability of coccidial oocysts by artificial excystation of sporozoites.

1961. Discovery that different breeds of chickens differ significantly in their susceptibility to blackhead.

1961. Evaluation of comparative susceptibility of calves and adult cattle to bovine anaplasmosis, which now determines the pattern of testing herds for control of this disease.

1962. Adaptation of direct fluorescent antibody technique to the study of anaplasms.