F. D. Enzie, Antiparasitic Investigations, AFL September 23, 1959

Through : A. O. Foster, Head, Antiparasitic Investigations, AFL

Edwin R. Goode, Jr., Acting Director, ADP

A Print on "Veterinary Medicine of the United States and Its Contributions to American and World Health and Welfare"

The Division has been requested to participate in the preparation and compilation of material for the subject matter. This print is for the use of Senator Hubert H. Humphery of Minnesota. The proposed deadline for this material is October 10, 1959. It is proposed that we meet in the Library at the Animal Disease Station, at 9:00 a.m., on September 24, for discussion of the subject.

It is expected that you will need the assistance of other members of the staff of the parasitological laboratory. This office would suggest that they cooperate to the extent that the material can be in the hands of Dr. Osteen, who has been designated to assemble the data for the Division, not later than October 9, 1959.

Informative material on the subject will be available at the meeting tomorrow.

cc: J. S. Andrews
L. A. Spindler

B. Accomplishments and their significance

Citation of specific accomplishments of past and present work

Significance of accomplishments should be related to:

A. Welfare of Man

B. The Health of Man

C. The Forign Relations of the United States

D. The prestige of the United States and Its Scientists

E. Other significant relationships if any should be pointed out.

C. Major Problem Areas

A. Describe some of the barriers that must be overcome before full utilization can be made of the contributions of Helminthology in helping to solve problems of the major areas listed in Items A, B, C, D, and E, above.

D. Opportunitites

A. Examples should be cited to specify opportunities that exist for further contributions through helminthology to the major areas listed in items A, B, C, D, and E. above.

It is possible that these opportunities would be realized only if appropriate conditions were provided. Attention should be drawn to the need for these conditions and how they might be realized.

In categories under helminthology or general statement at beginning of article?

Development, Standardization, and Evaluation of Antiparasitic Agents

(A) Nature of Work

1. History and Evolution

Parasites of livestock have been responsible for enormous losses to mankind ever since the domestication of animals was undertaken. These losses occur in all parts of the country, indeed in all areas of the world, and in all seasons. Some kinds of parasites are important primarily for economic reasons, as reflected in increased costs of production of animal foods and by-products, while others may be transmitted directly to man resulting in the development of debilitating or fatal disease. The control or eradication of these pests, therefore, contributes to a sound economy, a high standard of living, and a healthy populace.

In the years preceding World War I, remedies available to stockmen were limited in number and of doubtful, or at least undetermined, value. This was due, in large measure, to the lack of suitable methods of assaying the usefulness of antiparasitic agents and to the absence of standards of usage and performance of the remedies available. In 1915, M. C. Hall, a scientist in the U.S.D.A. Bureau of Animal Industry, inaugurated the era of critical testing of anthelmintics, remedies active against helminths or worm parasites. He devised, standardized, and popularized an accurate method of ascertaining the efficiency of these agents in the specific host animal. Briefly, the procedure entails (a) the administration of a measured dose of the drug in question to a suitable test animal; (b) the collection, identification, and enumeration of all worm parasites eliminated after treatment; (c) after an interval

of several days, the slaughter and recovery of all worm parasites remaining in the test animal; and (d) determination of the percentage efficacy by arithmetical calculation. This method promptly attained world-wide acceptance and has remained the basic testing procedure for the development, standardization, and evaluation of anthelmintics for livestock and poultry. Information obtained in this manner provides a background of information on which to establish, in part, the net superiority of one drug over another and permits the rational employment of anthelmintics as adjuncts to parasite control. The basic concepts of Hall's critical test for anthelmintics are utilized also in the evaluation and standardization of other kinds of antiparasitic agents.

During the decade following the development of Hall's critical test, a major effort was directed toward the evaluation of available worm medicines with the result that many were determined to be worthless. This information saved stockmen untold sums of money that otherwise would have been invested in them. Although the need for this kind of testing has diminished somewhat over the years, the basic problems remain and prudence dictates continued efforts in this regard.

In the development of new chemical treatments for parasitic infections, the initial efforts were directed primarily against specific parasites that were known, or presumed, to be most injurious. The removal of these pests from heavily parasitized animals seemed to be the most direct and rewarding approach. As a result of these efforts, a number of treatments were developed which served a very useful purpose

in an expanding livestock industry. In the last two decades, however, the concepts of parasite control have changed with the ever-increasing accumulation of information on parasites and the diseases caused by them. The damage caused by the larval or immature stages of many parasites often exceeds that of the adults; and as a consequence, prevention of infection rather than attempts to salvage heavily parasitized animals has become the primary objective in the campaign against these avoidable losses. The use of specific treatment in parasitized animals remains an important part of parasite control programs, however, since it is an effective means of reducing sources of infection by removing the egg-laying stages of the parasite.

2. Purpose and Objectives

Parasites, both internal (such as roundworms, tapeworms, flukes, and protozoa) and external (such as flies, lice, ticks, and mites) cost livestock producers in the United States alone over one billion dollars annually. This figure, based upon estimates made in 1954 by the U. S. Department of Agriculture, is highly conservative. It reflects, primarily, mortality (death) and morbidity (illness) losses and does not take into account such important intangibles as costs of drugs, professional services, labor, control programs, and research.

The use of drugs, either as specific treatments or in accordance with planned programs of preventive medication, is the most reliable and practical means of combatting losses ascribable to parasitic infections. The primary purpose of antiparasitic investigations, therefore, is to discover, develop, and standardize efficient treatments for parasitic

diseases of livestock and poultry and to devise practical measures of control. In this connection, only a few of presently available chemical agents may be considered primary choices for the treatment or control of parasitic infections, and none approaches the ideal. Frequently, available treatments can be recommended only provisionally, and in many instances no treatments at all are available for important parasite species. The principal objectives, therefore, are directed toward the improvement of presently available treatments, the discovery and development of treatments against parasites that do not respond to present-day drugs, the development of effective preventive measures, and, eventually, the control or eradication of all harmful parasites affecting man and animals.

3. Current Work

The current research program pertaining to antiparasitic investigations is directed toward the three major parasite groups, namely, worm parasites, protozoan parasites, and arthropods. The work in all groups is concerned primarily with the discovery and development of new antiparasitic agents; the standardization of certain newer remedies; the comparative evaluation of available alternative treatments on the basis of safety, value, simplicity, and cost; and the development of practical chemical control programs for all important parasitic infections of livestock and poultry.

(B) Accomplishments and Their Significance

(1) The development of the so-called critical test for evaluating worm remedies (referred to previously) in 1915 was a monumental accomplishment in the area of antiparasitic investigations. This procedure provided for the first time an accurate method of ascertaining the efficiency of these drugs and formed a basis for comparatively evaluating alternative treatments. In consequence of this pioneer work, new emphasis was given to an important area of medical research throughout the world. Scientists in all countries have used the basic principles of the test to develop and evaluate more efficient and reliable treatments for the control of parasitic diseases in both man and animals.

(2) The discovery in 1921 by scientists in the U.S.D.A. of the markedly efficient action of carbon tetrachloride against hookworms in dogs and its subsequent use against related species in man was an achievement of unusual significance. The drug has been used in all parts of the world where hookworm disease occurs, contributing immeasurably to the health and welfare of untold millions of people. Moreover, a continuous succession of discoveries of further uses of this chemical lead to its wide-scale employment against a variety of helminthic parasites of livestock throughout the civilized world. Indeed, it remains today the treatment of choice against the common liver fluke of sheep and is an alternative treatment for certain other worm parasites.

Continuing investigations by Government researchers with related hydrocarbons resulted in the discovery in 1925 that tetrachlorethylene

had all the advantages of carbon tetrachloride but carried less risk of intoxication to the patient. This drug has remained for over a quarter of a century the standard treatment for human hookworm disease in many parts of the world.

Later studies in the U.S.D.A. and elsewhere showed that this drug also had important antiparasitic applications in ruminants and other animals.

(3) The development of phenothiazine for the control of parasites in all kinds of farm animals, including poultry, marks the most important milestone in the history of chemical attack on these pests. Following the discovery of its anthelmintic action in 1938 by scientists in the U.S.D.A., and of applications of its antiparasitic effects in all classes of livestock, phenothiazine became the principal drug used against gastrointestinal roundworm parasites throughout the world. It combines an unusual margin of safety and wider range of action in more classes of livestock than any other drug. Savings to the livestock industry in this country, as well as in all parts of the world, are incalculable; but it has been credited with saving sheep raisers in one State alone nearly five million dollars annually.

The world-wide acceptance of the drug and recognition of its importance to the livestock industry everywhere is reflected in the more than 100 scientific papers published annually on various aspects of its antiparasitic effects. Phenothiazine, moreover, is destined to remain a highly important factor in livestock production for many years despite

the unrelenting search by workers in all areas of the globe for a new chemical of even greater value. For several years the chemical was also used against pinworm infections in man.

(4) The development of the sodium fluoride treatment for removal of large roundworms from swine in 1944 by workers in the U.S.D.A. was a major contribution to the solution of one of the most serious problems of swine producers. This treatment possessed to an unprecedented degree the attributes sought in an ideal anthelmintic. When used as recommended, it is safe to administer, highly effective, simple to employ, and very inexpensive. Moreover, the chemical is rapidly eliminated from edible tissues of treated animals and consequently is not a hazard to the consumer. The sodium fluoride treatment has been widely used in all important swine-raising areas of the world and has contributed immeasurably to the economic welfare of man. Although other worm remedies had been administered to swine in feed before the development of the sodium fluoride treatment, none was employed as effectively nor as widely as the latter chemical. The successful employment of sodium fluoride in this manner for the control of the most injurious worm parasite of swine obviated the need for individual treatment and set the standard for subsequent developments in the medication of swine for the control of worm parasites.

(5) Further examples, but by no means all, of accomplishments in the field of antiparasitic investigations are;

1917--Development of oil of chenopodium for the removal of large roundworms from swine. This drug became the treatment of choice in all important

swine-raising areas of the world and retained this position until supplanted in about 1945 by sodium fluoride. The drug was also shown to be effective against certain worm parasites in horses, dogs, and other animals.

--Evaluation of carbon disulfide as a highly effective treatment against stomach bots of horses. This chemical is used in all areas of the world and remains the most widely recommended treatment for the removal of these parasites from horses. Later investigations by U.S.D.A. researchers established its usefulness also against large roundworms of horses and swine.

1919--Development of the copper sulfate treatment for removal of large stomach worms from sheep, goats, and cattle. This treatment promptly attained world-wide usage and has been given to untold millions of animals. After 40 years, moreover, it remains one of the commonly employed remedies against stomach worms, among the most injurious of all parasites attacking farm animals.

1932--Development of n-butyl chloride as an agent for removing the common intestinal roundworm parasites of dogs. This chemical exhibited a wider range of action against these parasites than either carbon tetrachloride or tetrachlorethylene and remained the drug of choice for the removal of large roundworms, hookworms, and whipworms for several years.

1934--Discovery of stibophen as a useful treatment for controlling heartworms of dogs. This drug became the standard treatment for heartworm infections throughout the world and retained this position until the accelerated

research program during World War II lead to the development of its successor, arsenamide, by researchers at the Johns Hopkins University in Baltimore.

1939--Discovery and development of barium antimonyl tartrate as an effective treatment for controlling gapeworms of poultry. This parasite is prevalent in all parts of the country as well as abroad and frequently causes severe losses among infected birds, particularly chickens and pheasants. The treatment is highly efficient and is the only one known for this condition.

1941--Development of sulfaguanidine for the treatment and control of coccidiosis of sheep, a disease causing bloody diarrhea and death in feed lot and farm lambs. The drug was subsequently tested against similar diseases of calves and chickens with unprecedentedly beneficial action in both instances. Discovery of the marked efficiency of this type of compound was a highly significant break-through in the treatment of this disease and lead to major advances in the chemotherapy of coccidial infections of domestic animals and poultry.

1943--Development and standardization of the hexachloroethane drench for the destruction of liver flukes in cattle. Many stockmen in the Gulf Coast area of the United States reported that this treatment solved one of their principal parasite problems. It is the treatment of choice for liver flukes in all cattle-raising areas of the world where this parasite is found. The chemical is a useful alternative treatment against liver flukes in sheep and is effective also against certain roundworm parasites in sheep, goats, and cattle.

1945--Development of the winter-treatment program with phenothiazine for the control of nodular worm disease of sheep. This project was designed as a major contribution to the war effort at a time when the country was facing a shortage of surgical suture material. At that time, a large proportion of these sutures were made from sheep casings but those showing nodules produced by the larval stages of the parasite were useless. The method proved a remarkably satisfactory solution to the immediate problem; but more importantly, it lead to the world-wide acceptance by stockmen of preventive medication against parasites.

1950--Development of the portable pen program for reducing mortality of dairy calves. This system resulted in major savings in calf crops of dairy herds in areas where death losses from coccidiosis and other filth-borne diseases were threatening the economic existence of the enterprise.

1955--Development of spray-dipping as a new method of eradicating external parasites of livestock. This provided a rapid, efficient, and economical method of treating large numbers of animals with mobile equipment.

1956--The demonstration of dusting as a safe, efficient, and simple method of eradicating external parasites of sheep. This procedure permits the treatment of these animals during periods of inclement weather when dipping and spraying are contraindicated.

1957--The demonstration that systemic drugs, particularly organophosphates, are effective against nose bots of sheep. Heretofore, the treatment of infested animals was extremely laborious and not particularly effective.

--The establishment of mange mites of sheep and cattle experimentally in rabbits. This permits economical investigations of potential antiparasitic

agents as well as of the biology of the organisms.

---Development of an *in vitro* technique, using serum from medicated bovines and sheep nose bot larvae as test organisms, to assay miscellaneous chemicals as potential systemic treatments against cattle grubs. These studies ordinarily require 8 to 9 months for evaluation of results because of the long period that these parasites ordinarily spend in the tissues of the natural host.

It is abundantly clear that these several examples of fruitful research in veterinary science by workers in the U.S.D.A. contribute immeasurably to the economic and personal welfare of man by providing safe, effective, simple, and inexpensive measures for controlling important animal diseases. This provides for healthy livestock and poultry and results in a progressive, prosperous, and productive agricultural industry. Some, moreover, have contributed directly to man's health and general welfare by demonstrating the significance of animal experimentation as a proving ground for human treatments of parasitic infections. This is exemplified by the carbon tetrachloride and tetrachloroethylene treatments for hookworm disease.

These contributions to agriculture and the welfare of man in this country are applicable also in other parts of the world. This is clearly demonstrated by the ready acceptance and wide-scale employment of these findings and developments in other countries, thus exercising a very favorable influence on the economic status, health, and general welfare

of these peoples. This is one area in which the United States and its scientists have always been and continue to be the acknowledged leaders among the nations of the world. Many foreign scientists have come to this country to study our methods of research, to discuss our findings, to exchange ideas, and to seek solutions to perplexing problems in the field of parasitism. These visitations, together with reciprocal exchanges by scientists of the United States, have proved to be of mutual and lasting benefit.

It should be recognized that, by and large, specific treatments for parasitic diseases are products of the times and for the times. Many drugs in common use a decade or so ago have been replaced by safer and more efficient ones. An even greater change will undoubtedly occur a decade or so hence. In this connection, the record clearly shows that Government scientists have made an envisble record in this important area of agricultural research. This has been accomplished, moreover, in spite of very limited budgets, insufficient personnel, and inadequate facilities. Savings attributable to phenothiazine alone in one State and for one year have exceeded the total budget for parasitological investigations in the Animal Disease and Parasite Research Division, A.R.S., for the past ten years! And funds available for antiparasitic investigations have constituted a relatively minor part of the budget provided for all of the parasitological work of the Division. In the years since 1915, most of the antiparasitic chemicals and measures in wide usage have been developed or standardized in the U.S.D.A. in which connection it might be pertinent to observe that the extent of parasitological research in other

countries, notably Russia and Poland, far exceeds our own. The Russian Helminthological Society, for example, has a membership of from 1500 to 2000 whereas the American Society of Parasitologists, which serves the entire field of parasitology, has only about 1200 members.

(C) Major Problem Areas

As of today, the major problem in the field of chemical control of parasitic diseases is the development of measures to achieve the desired result with minimal reliance on foreign chemicals.

The comparative dearth of basic information on the mechanism of drug action, the physiology of parasites and the influence of chemicals thereon, and the relationships between the nature of chemical compounds and their biological effects are all fundamental issues that require elucidation. Information obtained on these matters will permit the establishment of a solid foundation for the rational development and use of antiparasitic agents and measures.

(D) Opportunities

In spite of significant developments and findings in the chemical control of parasites, there remain many voids and deficiencies of drugs that may be used safely, effectively, and economically in food animals. The shortcomings recognized in the best of available antiparasitics clearly show the need for new and improved chemical agents to combat these pests. Satisfactory treatments are still lacking for many important parasites of livestock and poultry, notably, kidney worms of swine, lungworms of swine, horses, and ruminants, threadworms of ruminants and swine,

demodectic mange mites in all animals, and such protozoan diseases as trichomoniasis of cattle and poultry, anaplasmosis of ruminants, and histomoniasis of poultry.

A particularly serious deficiency among presently available worm remedies is reliably effective action against immature stages, particularly the tissue-dwelling species. This suggests the need for greater emphasis on the development of systemic drugs, not only for possible action against the aforementioned immature or larval stages, but also against such relatively inaccessible species as liver flukes, kidney worms, lungworms, genital trichomonads, and demodectic mange mites. In this connection also, mention should be made of the need for more intensified investigation of the prophylactic use of chemicals to prevent the invasion and establishment of parasites in the host animals, to prevent the development of infective stages from eggs passed in the feces of infected animals, and to destroy the infective stages on contaminated premises and pastures.

The ever-increasing emphasis on the hazards of chemical residues in edible tissues and animal by-products of treated animals suggests the need for developments along entirely different lines of approach to the parasite control problem. The establishment of programs involving chiefly sanitation and management practices, with minimal reliance on the use of chemical agents, should be investigated thoroughly. The use of immunological methods and procedures holds much promise in this important area of livestock production.

Accomplishments of Antiparasitic Investigations

Since the methods and treatments listed below pertain to the control of the protozoan and helminthic parasites the morphological, taxonomic, and biological investigations of which have just been summarized, they have been included as part of the information requested.

1915. The so-called critical test for evaluating worm remedies was developed. This test was a monumental accomplishment and provided for the first time an accurate method for ascertaining the efficiency of these drugs and formed a basis for comparatively evaluating alternative treatments. This pioneer work gave new emphasis to an important area of medical research throughout the world and enabled scientists everywhere to develop and evaluate more efficient and reliable treatments for the control of parasitic diseases in both man and animals.

1917. Oil of chenopodium was first used for the removal of large roundworms of swine. Until the discovery of solium fluoride, it was the treatment of choice. It was also effective against certain worm parasites in horses, dogs, and other animals.

Carbon disulfide was evaluated as a highly effective treatment against stomach bots of horses. Later investigations established its usefulness against large roundworms of horses and swine.

1919. The copper sulfate treatment for the removal of large stomach worms from sheep, goats and cattle was developed. It still remains one of the commonly employed remedies against stomach worms, among the most injurious of all parasites attacking ruminants.

1921. The discovery that carbon tetrachloride was an effective remedy for the removal of hookworms from dogs. Subsequently it was used against hookworms in man and remains today the treatment of choice against the common liver fluke of sheep and is an alternative treatment for certain other worm parasites.

1925. Tetrachlorethylene was found to have all the advantages of carbon tetrachloride but carried less risk of intoxication. It is still used as a standard treatment for hookworms in man and has antiparasitic applications in ruminants and other animals.

1932. n-Butyl chloride was developed as an agent for removing the common intestinal roundworm parasites of dogs. This chemical exhibited a wider range of action against these parasites than either carbon tetrachloride or tetrachlorethylene and remained the drug of choice for the removal of large roundworms, hookworms, and whipworms for several years.

Accomplishments (Antiparasitic Investigations) - Continued

1938. Phenothiazine was discovered and is used for the control of parasites in all kinds of farm animals, including poultry. This discovery marks the most important milestone in the history of chemical attack on internal parasites. Savings to the livestock industry in this country, as well as in all parts of the world, are incalculable, but it has been credited with saving the sheep raisers in one state alone nearly $5 million annually.

1939. Discovery and development of barium antimonyl tartrate as an effective treatment for controlling gapeworms of poultry.

1941. Development of sulfaguanidine for the treatment and control of coccidiosis of sheep. The discovery of the marked efficiency of this type of compound was a highly significant break-through in the treatment of this disease and led to major advances in the chemotherapy of coccidial infections of domestic animals and poultry.

1943. Development and standardization of the hexachloroethane drench for the destruction of liver flukes in cattle. It is the treatment of choice for liver flukes in all cattle-raising areas of the world where this parasite is found. The chemical is a useful alternative treatment against liver flukes in sheep and is effective also against certain roundworm parasites in sheep, goats and cattle.

1944. The development of the sodium fluoride treatment for the removal of large roundworms from swine was a major contribution to the solution of one of the most serious problems of swine producers.

1945. Development of the winter-treatment program with phenothiazine for the control of nodular worm disease of sheep. This program led to the worldwide acceptance by stockmen of preventive medication against parasites.

1947. The development of toluene as an agent for the removal of large roundworms and hookworms from dogs and cats. This chemical is still widely used in this country and abroad despite the subsequent discovery of other agents having a similar anthelmintic spectrum.

1960. Bithionol was shown to be an effective treatment against common tapeworm species in the intestinal tract of dogs, cats, and sheep.

1962. The efficiency of bithionol against the fringed tapeworm of sheep was found to be superior to that of any other available drug. This parasite, which occurs primarily in the liver of sheep, is responsible for the condemnation of this organ as food for man.

Dr. Andrews

E. R. Goode, Assistant Director, Animal Disease and Parasite Research Division, ARS — June 20, 1958

A. O. Foster, Head, Parasite Treatment Section, ADP-ARS

Additions to "Agriculture Headline" Portion of Pace Committee Report

Herewith the two lists of items requested for purposes of amplifying and extending Agriculture Headlines of the Pace report. The lists combine items from all three parasitology sections.

Enclosures - 2

AGRICULTURAL HEADLINES 1945 - 1950 (Supplemental List)

1945--The lancet fluke of ruminants reported to be definitely established in the United States.

Feeding fluid skim milk to swine removes intestinal parasites.

Common amphistome fluke of ruminants in the United States recognized as a new species.

Nutritional status of lambs an important factor in coping with hookworms.

World-wide acceptance of methods of systematic preventive medication for controlling parasites of livestock and poultry.

Lead arsenate employed as treatment for ruminant tapeworms.

Chlorinated insecticides prove useful against livestock pests.

Improved hexachloroethane drench for treatment of liver fluke disease of cattle.

Cattle grub area control tested.

1946--System of hygienic breeding devised for control of bovine venereal trichomoniasis on farms.

New dips and sprays devised for eradication of cattle fever tick.

Precise cooking temperature for destroying tapeworm cysts in beef determined.

1947--Bovine venereal trichomoniasis spread by artificial insemination.
Toluene developed as anthelmintic for domestic animals.
Cecal coccidiosis of poultry brought under practical control.

1948--Wild rabbits act as reservoir hosts for the liver fluke of cattle in the Gulf Coast Region.

BHC dip used effectively to eradicate sheep scabies.

Systemic medication used against trichomoniasis in bulls.

Economic effect of worm parasites on pigs elucidated.

1949--Antibiotics in feed aid in control of poultry coccidiosis.

1950--Mortality of dairy calves reduced by use of portable pens.

Transmission of trichinae by feeding feces of recently infected animals demonstrated.

Items of Research Accomplishments 1951 - 1958 for Developing Agricultural Headlines

1951--Parasite and disease losses in rabbit production traced to poor management.

Experimental transmission of sheep scabies to cattle.

Antibiotics and vitamin B_{12} in swine feeds help combat parasites.

1952--Improved methods of diagnosing bovine venereal trichomoniasis developed.

Poultry coccidia in soil destroyed by applications of creosote.

Itch mite of sheep discovered in United States.

Follicular mange mite found in internal organs of a dog.

1953--First experimental prenatal infection of calf with ascarid of ruminants.

Pathogenicity and life cycles of cattle coccidia evaluated.

Severity of parasitism in grazing cattle influenced by nutritional level of forage.

1954--Chorioptic scabies eradicated from cattle by toxaphene.

Piperazines become prominent as anthelmintics.

Psoroptic cattle scabies in West checked with lindane dips and sprays.

Lice experimentally eradicated by injections of parasiticides into cattle.

Losses from parasitism of livestock estimated $1 Billion.

Lungworms fatal to cattle before diagnosis possible.

1955.--Venereal trichomoniasis discovered in range cattle.

Swine trichomonads a cause of abortion in cattle.

Rats carriers of atrophic rhinitis of swine.

Blackhead found to affect chickens as well as turkeys.

Spray-dipping developed as a new method of eradicating external parasites.

A systemic drug proves effective against cattle grubs in wide-scale tests.

1955--Criteria for differentiating immature parasitic nematodes of cattle established.

Injection of immune serum increases resistance of cattle to lungworms.

1956--Venereal trichomoniasis discovered in artificial insemination bull stud.

Coccidiosis now a cause of losses in Western range cattle.

Venereal trichomoniasis in Western range cattle now a cause of extensive breeding losses.

Intestinal trichomoniasis increases losses from coccidiosis in poultry.

An antibiotic found efficient as an anthelmintic in swine.

Dusting proved a safe, efficient, and easy method of eradicating external parasites of sheep.

Modification of the pathogenicity of one parasite by another.

1957.--Swine trichomonads a new cause of venereal trichomoniasis of bulls.

Intestinal worms increase losses from coccidiosis in farm calves.

Tick fever parasites of cattle found in wild deer in United States.

Wild raccoon in United States a reservoir of an injurious, exotic blood parasite of human beings.

Systemic drugs prove effective against sheep nose bots.

Organophosphate parasiticides show broad-spectrum action against both external and internal parasites of cattle and sheep.

Stilbestrol reported to increase susceptibility of cattle to internal parasites.

Small doses of infective lungworm larvae protected calves against otherwise lethal doses of this parasite.

Infectiousness and reproductive capacity of stomach hairworms of cattle were increased by exposure of the infective larvae to X-ray.

1957--Cross-transmission of certain nematode parasites of swine and cattle and their pathogenicity in the abnormal host demonstrated.

Pathogenicity of intestinal threadworm of sheep demonstrated.

1958--Clarification of pathogenicity of intestinal hairworms of sheep and cattle.

Embryo of fringed tapeworm of sheep reported to undergo partial development in insects related to "book lice."

Type of forage influences vertical migration of parasitic larvae of nematodes of cattle and swine.

New coccidiostats for poultry evaluated.