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OUTLINE FOR CONTRIBUTION OF

HELMINTHOLOGICAL INVESTIGATIONS

TO

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"VETERINARY MEDICINE OF THE UNITED STATES AND ITS CONTRIBUTIONS TO AMERICAN AND WORLD HEALTH AND WELFARE: ACHIEVEMENTS, PROBLEMS, AND OPPORTUNITIES"

(A) 1. History and Evolution:

The economic importance of worm parasites of livestock was brought to the attention of the Federal government as early as 1878 when reports were received by the State Department that pork exported to Europe from the United States was considered to be dangerous to human health because of the presence of trichinae. The threatened loss of this foreign market for our surplus pork which at that time could not be consumed by our relatively small population and increasing by numerous reports of the ravages of parasites and parasitic diseases from the livestock producing areas of our own country finally brought about the establishment of the Zoological Laboratory within the Bureau of Animal Industry in 1886. The rapid increase in the work of this laboratory resulted in its attaining the status of a Division in 1891. Most of the early work on helminths was taxonomic in nature and was located in the Department of Agriculture in Washington, D. C. However, worm experimental work requiring large farm animals was conducted at the Bureau's Experiment Station at Bethesda, Maryland. In 1930, the first unit of the Animal Parasitology Laboratory was completed at the Agricultural Research Center, Beltsville, Maryland. With the establishment of this laboratory controlled experimental work on life histories and pathogenicity of worm parasites of large animals and poultry could be carried out.

The investigation of helminths and helminthic diseases of livestock and related animals was one of the principal activities of the Zoological Division until it was split into sections, each covering a single scientific discipline in 1953. The work on helminths then became the responsibility of the Helminth Section of the newly formed Animal Disease and Parasite Research Branch of the Agricultural Research Service. In 1956 the Branch became a Division and the Helminth Section was renamed the Helminthological Investigations Research Group.

In 1886 helminthological research was done by one man; in 1958 there were 19 professional Federal employees and several parasitologists and veterinarians trained in parasitology located at State Experiment Stations and Universities engaged in this work. Twelve of the Federal employees were at Beltsville, the others were located at three field laboratories at Auburn, Alabama, Tifton, Georgia, and University Park, New Mexico, and at Experiment, Georgia and State College, Mississippi. The additional work was carried on in cooperation with State Agricultural Experiment Stations in California, Kentucky, Montana, Nebraska, North Carolina and North Dakota. In 1886 the estimated total annual expenditure for this work was approximately $2,000; in fiscal year 1958 the net amount received for helminthological research was just under $344,000.

(A) Nature of Work:

2. Purpose and Objectives:

To plan and conduct fundamental and applied research on the worm parasites of domestic livestock and poultry, and related wild animals and birds, within the field of helminthology as well as in cooperation with specialists in related scientific fields. The objectives are (1) to identify the helminth parasites of domestic livestock; (2) to determine their spread; (3) to study their biology, ecology, and life histories, their vectors, methods of infection,

physiology, and the nature and extent of the losses caused by them, including their interrelationships with other disease producing agents; (4) to obtain factual data on their economic importance to the livestock industry; (5) to obtain information needed to formulate practical biological control measures against them; and (6) to develop such control measures on the basis of the facts obtained.

(A) Nature of Work:

3. Current Work:

The present work in helminthological investigations is organized on a host basis under work projects entitled: Parasites and Parasitic Diseases of Cattle, Parasites and Parasitic Diseases of Sheep and Goats, and Parasites and Parasitic Diseases of swine, and Parasites and Parasitic Diseases of Poultry and Game Birds respectively.

The research on cattle helminths is being carried on at Beltsville, Maryland, at the Regional Laboratory at Auburn, Alabama, including substations at Experiment, Georgia, and Starkville, Mississippi, at University Park, New Mexico, and in cooperation with Agricultural Experiment Stations in Kentucky and California.

The present program includes investigations of (1) the relative pathogenicity of infections consisteing of single versus multiple helminth species on calves and the effect of the presence of one species on others; (2) factors influencing the development, migration, and survival of worm parasites on pasture; (3) relationship between diet and susceptibility to gastrointestinal helminthiases; (4) effect of type of forage plant, pasture management and season on the intensity of infestation and longevity of helminth parasites on pastures;

(5) physiological effect of helminths on bovine metabolism; (6) the production of immunity to cattle lungworms and gastrointestinal helminths with normal larvae, larvae attenuated with x-ray irradiation, adult parasites and immune serum; (7) survival of eggs of the beef tapeworm under various environmental conditions; (8) study of the food requirements of free-living stages of cattle helminths; and (9) methods for growing parasitic stages of cattle helminths to egg-laying maturity in sterile artificial media outside the host.

The research on sheep and goat helminths is being conducted at Beltsville, Maryland, at the Regional Laboratory at Auburn, Alabama, including the sub-station at Starkville, Mississippi, at University Park, New Mexico, and in cooperation with Agricultural Experiment Stations in Kentucky, Montana and North Dakota.

The present program includes investigations of (1) the effect of various systems of pasture management on non-irrigated and irrigated pastures on the acquisition of helminth parasites by sheep; (2) the flock pathogenicity of strains of stomach worms from wild ruminants and of stomach hairworms of the horse in sheep as compared with that of sheep strains of these parasites; (3) the life history and pathogenicity of the thread lungworm of sheep and goats; (4) physiological changes in the serum proteins of sheep resulting from helminth infections and their relation to the development of immunity to these parasites; (5) the life-history of the fringed tapeworm and the mode of infection of sheep, with this parasites; and (6) the relative susceptibility of sheep and goats to the helminth parasites that are common to both hosts.

The research on swine parasites is conducted at Beltsville, Maryland, Tifton, Georgia, and in cooperation with the University of Nebraska, and the University of North Carolina.

The current program includes investigations on (1) the effect of herd management on the control of kidney worm infection in the South; (2) the production of a dependable antigen for the diagnosis of kidney worm infection in swine during the prepatent period; (3) longevity of swine whipworm eggs on and in soil; (4) the life histories and pathogenicity of the whipworm, red stomach worm and nodular worms of swine; (5) the possible use of fertilizers and other agricultural chemicals as agents for the destruction of the free-living stages of swine helminths on pastures; (6) cross transmission of swine helminth parasites of non-porcine hosts to swine; (8) the relative pathogenicity of these helminths in the transfer host; (9) studies on the pathogenicity of the large roundworm in disease-free pigs; and (10) the effect of storage of trichinous pork for long periods at relatively low but non-freezing temperatures on the resistance of trichinae to subsequent freezing.

The research on poultry helminths is being conducted at the Beltsville Parasitological Laboratory.

The current research includes investigations of (1) the life history and pathogenicity of intestinal threadworms of chickens; (2) the life history of ascarids of poultry; and (3) the relative pathogenicity of different species of tapeworms of poultry.

(B) Accomplishments and Their Significance:

The helminth parasites of livestock in the United States and the diseases caused by them were largely unknown in 1886 when this work began. Trichinosis in swine, verminous bronchitis and liver fluke disease in cattle, fringed tapeworm infection in sheep, and gapeworm disease in poultry were recognized but the identity of many of the parasites, their distribution, life histories, nature and extent of their pathogenicity, their economic significance, and measures for their control were unknown.

Veterinary parasitologists of the Department of Agriculture have played and are still playing a tremendous part in clearing up the disease problems caused by worm parasites. Of the estimated 58 new genera and 216 new species of helminths described by these investigators, fully one-fourth parasitize our domestic animals and poultry.

As early as 1887 the results of studies on flukes in the liver and lungs of cattle, pointing out their causative relationship to lesions in the viscera of infected animals, were published. In 1889 the disease caused by the fringed tapeworm of sheep, Thysanosoma actinioides, was first described and in 1890 the common nodular worm of sheep, Oesophagostomum columbianum, was described for the first time and was shown to be the cause of nodular disease or "knotty guts" of sheep. In 1944 this parasite was shown to cause stunting, and deterioration in the quality of wool produced by lambs which survived moderate to heavy infections.

In 1894 a summary of outbreaks of liver fluke disease in domestic livestock was published.

In 1895 a report on the rarity of the pork tapeworm, Taenia solium, was published.

In 1898 the Zoological Division published a bulletin on flukes and tapeworms of cattle, sheep and swine, with special reference to the inspection of meats. This was the first publication of the Department dealing generally with the helminth parasites which invade the flesh and viscera of carcasses of meat-producing animals thus rendering them unfit for human food.

As early as 1900 a report was published on the kidney worm of swine and its importance as a cause of widespread damage to hog carcasses. In 1912 studies on the nematodes of swine and the injuries caused by them demonstrated the economic importance of the kidney worm as a cause of widespread condemnation of hog livers, loins, kidneys and kidney fat. Later in 1929 a modified swine sanitation system was shown to be applicable to controlling kidney worm infection in the South, but that it was not as successful as in the control of ascarid infection. A small scale experiment has recently shown that kidney worm infection can be eliminated from pigs fed in a dry lot contaminated with larvae of this parasite by using gilts that are not infected with kidney worms for two or three semi-annual farrowings on the same premise.

In 1901 papers on hookworm disease in man and animals in the United States and on trichinosis were published. The second paper disproved the contention of German authorities that trichinosis in Germany was acquired by eating pork that was imported from the United States, and showed that it was acquired by eating pork that was native to Europe. It also demonstrated that the microscopic inspection of pork for trichinae was not an effective means for ascertaining that a carcass was not infected with this parasite.

Probably the most important single contribution of this research was the discovery of a new hookworm, Uncinaria americana Stiles 1902. This nematode, later called Necator americanus, was shown by Dr. C.W. Stiles, then Chief of the Zoological Division, to be responsible for much of the illness of people in many parts of the South. He demonstrated that much of the laziness and shiftlessness ascribed to these people was due to infection with this hookworm. This discovery resulted in great improvements in the health conditions and economic status of people in rural communities in the South by bringing about a campaign for hookworm eradication. This campaign was so successful that the worldwide campaign for hookworm eradication, sponsored by the International Health Board some years later, was undertaken. This entire program, beginning with the recognition of the parasite causing the disease, had its origin more-or-less directly in the hookworm investigations of Dr. Stiles. Furthermore, this parasite which was once thought to be found only in the Western Hemisphere has since been discovered in tropical and semi-tropical countries throughout the world.

In 1904 a nematode, Strongylus quadrirediatus Stevenson 1904 was reported to be the cause of losses among pigeons and the tapeworm, Davainea echinobothrida, was demonstrated to be the cause of nodular disease of the intestines of American chickens.

In 1905 the first well authenticated case of gid in sheep was reported from the United States. In 1910 the distribution of the gid tapeworm in the United States was ascertained and the coyote shown to be the host of the adult tapeworm, Multiceps multiceps. A historical review of the gid parasite and allied parasites was also published and a Federal quarantine on imported sheep dogs was established to prevent the introduction of dangerous worms.

In 1906 the life history of the large stomach worm of sheep, Haemonchus contortus, was described and in 1910 the first program for the control of this parasite was proposed. In 1942 the injury produced by this parasite was shown to be largely due to gastric hemorrhage.

In 1907 the development in the intestine of adult nematodes of the genus Strongyloides following cutaneous infection was reported.

In 1911 the investigation of beef measles was begun to determine meat inspection procedures to be used for its detection. In 1914 a method for the destruction of Cysticercus bovis by refrigeration was published. This work enabled many carcasses to be saved that previously were condemned as unfit for human food.

The discovery in 1911 of the life history of a stomach worm of horses, Habronema muscae, enabled European and Australian scientists to solve the problem of the cause of "summer sores" of horses. It was discovered that these lesions were caused by the larvae of this parasite which developed in house flies.

In 1914 the destruction of trichinae by refrigeration of infected pork was reported as a control measure for trichinosis, and in 1919 the thermal death point of trichinae was established and regulations formulated for the proper handling of cooked pork products in packing houses. In 1920 methods of curing pork were ascertained as effective in destroying trichinae and studies were published showing that these parasites could be attenuated or killed by the use of X rays. It is significant to note here that prior to the development of the procedures noted above, no satisfactory method for destroying these parasites was available for commercial use.

In 1917 new facts were discovered in the life history of the large roundworm of swine, Ascaris lumbricoides, including the fact that ascarid larvae may cause serious or fatal pneumonia in the course of their migration through the lungs of young pigs and the fact was established that no intermediate host was necessary for their development. In 1919 larval ascarids were reported as a common cause of so-called "thumps" in baby pigs. In 1927 a full report of the successful development of the McLean County Swine Sanitation System for the control of large roundworms and other parasites of hogs was published.

In 1919 turkeys were found to be largely responsible for the infection of chickens with the gapeworm which was relatively non-pathogenic to turkeys but was extremely injurious to chickens. These studies were most important in the control of this parasite.

In 1920 the intestinal nematode, Cooperia punctata, was shown to be the cause of severe lesions of the digestive tract in calves which resulted in serious injury and death. Studies on the toxins of parasitic worms and their effects on the blood of the host were also published.

In 1922 the intestinal threadnecked worm, Nematodirus spathiger, was reported to cause serious injury to sheep, and in 1953 the results of experimental studies on the pathogenicity of this parasite confirmed the earlier observations.

In 1923 the first successful experimental intrauterine infection of pups with dog ascarids was reported. Shillinger + Crom JAVMA 63 ns 16(2) 200-203

In 1924 nodular typhlitis of pheasants was found to be caused by a nematode, Heterakis isolonche, and in 1925 Heterakis biramporia was reported to cause intestinal nodules in chickens.

In 1926 the trematode involved in salmon poisoning in dogs was first described.

In 1928 the nematodes of pathological significance found in some economically important birds in North America was published.

In 1930 descriptions of pathological conditions of poultry ascribed to nematodes were published, and in 1931 the feeding habits and pathogenicity of the large-mouthed bowel worm of sheep were described.

In 1934 procedures for the control of kidney worms of swine in the South were published. [illegible] reported from the United States. [illegible] on the intestinal threadworm of swine [illegible] for the control of this parasite. [illegible]

In 1943 the extreme pathogenicity of this parasite was verified experimentally.

In 1938 much information on the intermediate hosts of poultry tapeworms was published which was important in the control of these helminths.

In 1939 the first studies in the United States were made on the relationship between nematode infections and the host's nutrition and the pathogenicity of intestinal hairworms in sheep was demonstrated experimentally. This year also saw the publication of information on the survival and localization of the microfilariae of the dog heartworm in the host and on the nematodes of domestic fowl that are transmissible to wild game birds.

In 1940 studies indicated that the red stomach worm of swine was not particularly pathogenic to swine unless it was present concurrently with other disease agents.

In 1941 studies on garbage-fed hogs showed them to be more frequently infected with trichinae than were grain-fed hogs. Later studies after the passage of legislation requiring the cooking of garbage used for feeding swine, indicated that this procedure when done properly practically eliminated this parasite from the hogs in question. In this year the European lancet fluke was first reported in domestic ruminants in the United States and its dangerous potentialities were pointed out.

In 1942 the intestinal threadworm of swine was first reported to cause mortality in pigs, and the first comprehensive study of the incidence of the parasites of cattle in the United States was made in the southeastern states.

In 1943 the first experiments on the fumigation of soil to destroy larval stages of animal parasites were conducted.

In 1944 were published the first studies on the effects of trichostrongylosis on the nutrition of sheep.

In 1946 the important relationship between diet and the pathogenic effects of hookworms in sheep was demonstrated.

In 1948 the relationship between nematodes and skin lesions of domestic animals was described, and the serious interference with feed utilization of pigs by internal parasites was demonstrated. Also some of the cases of icterus in hogs resulting in their condemnation as unfit for food were found to be caused by the large roundworm which plugged the

bile duct of the liver. The fact that wild rabbits serve as reservoir hosts of the common liver fluke of ruminants was shown to be a vital factor in the control of this parasite in endemic areas.

In 1951 studies on the pathogenicity of the common sheep tapeworm were published.

In 1953 the threadnecked worm, Nematodirus spathiger, was shown to be very pathogenic to sheep and cattle were found to be adversely affected by larger numbers of immature gastrointestinal parasites in the South.

In 1954 the intestinal threadworm was shown to be the cause of death in calves.

In 1955 the stomach hairworm was shown to be very pathogenic to calves.

In 1956 studies on the course and pathogenicity of initial infections with cattle lungworms and on acquired resistance to this parasite were published.

In the same year it was shown that one species among those involved in multiple worm infections of the digestive tract of sheep may react with the others so that one or more of the other species is eliminated from the host. However, more recent studies in calves show that infections with two or three species of gastrointestinal helminths are more pathogenic than similar infections with one species.

In 1958 the intestinal threadworm of sheep was demonstrated to be a factor in the production of dysentery and was responsible for lung hemorrhages and anemia in sheep and goats. In this same year transmission experiments showed that the red stomach worm of swine will produce severe lesions in the abomasum of calves.

In 1958 and 1959 studies indicated that a rather high degree of immunity was conferred on calves by the administration of small doses of normal infective larvae of the cattle lungworm.

In addition to the contributions mentioned above there were many published descriptions of new species, and observations on life cycles and intermediate hosts, and on the survival of free-living stages of these parasites on pasture or soil, all of which have a bearing on the understanding and control of parasitic diseases in livestock. These must be omitted because of lack of space.

In 1961 the kidney-worm was eradicated experimentally from heavily contaminated pasture by using gilts only in the breeding herd and by disposing of them at the time their pigs were weaned. This was accomplished in 18 months to 2 years after the end of contamination

(c) Major Problem Areas

There are three major barriers preventing the realization of the maximum benefits that can be obtained from helminthological research. These are (1) failure on the part of the livestock owners and others to realize the economic importance of helminths and helminthic diseases of livestock, (2) unwillingness to cooperate in programs designed to test results of research performed on a small scale, and (3) lack of adequate financial support, trained personnel, and modern laboratory facilities.

(D) Opportunities

The major fields in which future contributions of research in helminthology to veterinary medicine and related sciences can be expected are as follows:

1. The histochemistry of helminth parasitism involving the histopathologic studies of disease processes under controlled experimental conditions. There is little doubt that information developed from such an approach will provide a much better understanding of disease.
2. Growth requirements of many parasites. The recent adaptation of tissue culture techniques for the growth of worm parasites may offer a means of obtaining a better understanding of disease processes and immunity.
3. Biological controls. Improvement and development of new immunizing agents.
4. Pathogenesis of single and multiple species infections.
5. More adequate study of economic losses caused by parasites and the economics of control programs, influences of production, feed conversion, and efficiency, and the significance of subclinical parasitism in cattle, sheep and swine.
6. Relation of nutrition and general well-being to susceptibility of livestock and poultry to helminth parasites, and the injuriousness thereof.
7. Environmental control of parasites by other than chemical means. Study of the ecology and bionomics of free-living stages of helminth parasites.
8. Chemical changes of body tissues and fluids in helminthic disease and in immunological response.
9. Fractionation of parasites and antibodies to develop more specific diagnostic tools.

10. Wild animals and birds as reservoirs of parasites affecting livestock and poultry.

11. Standards for diagnostic procedures as well as tools to cover new helminth diseases that arise.

12. Preservation of parasites and body tissues and fluids to make them readily available for long range studies.

13. Physiology of host-parasite relationship including the physiology of helminths and the alterations which these agents produce in the host.

14. Role of helminths as vectors of viral, bacterial, protozoal, and other diseases of livestock and synergic action between helminth and other causative agents of disease.

15. Application of physical science for the development of equipment for use in research on helminthic diseases.

16. Characterization of immunity and development of methods for measurement.

17. Relationship of genetic factors to susceptibility and/or resistance to helminths.