

Tapeworm and Roundworm Parasites of Cattle

BY DALE A. PORTER¹

SEVENTY or more species of tapeworms and roundworms infest cattle, some causing serious losses. Here are facts about the more important, including methods of prevention and treatment. The article on worm parasites of sheep should also be read by those interested, practically and scientifically, in cattle worms.

THE TAPEWORM and roundworm parasites reported to affect cattle throughout the world comprise over 70 different species. Although some species occur infrequently and others are comparatively harmless to their bovine hosts, some exact a heavy annual toll from the beef and dairy industries. Losses are due to deaths from gross parasitism, lowered vitality and resultant poor growth and performance, and condemnation, in the course of meat inspection, of carcasses or edible parts as a result of invasion by parasites.

Members of these two groups of parasites—tapeworms and roundworms—vary considerably in their location, structure, and harmfulness.

The cestodes, or tapeworms, of cattle are found as adults in the intestine and as larval forms in the muscles, liver, lungs, and other viscera. The adults are elongated, flattened worms consisting of a head and a chain of segments, each having both male and female reproductive organs, and terminal segments containing mature eggs. The larval forms, commonly referred to as bladder worms because they resemble a bladder in shape, are intermediate asexual stages of tapeworms that live as adults in the intestines of man and other animals. The bladder worms vary in diameter from one-fourth inch in the case of the beef bladder worm (*Cysticercus bovis*) to as much as 6 inches in the case of the hydatid cysts (*Echinococcus granulosus*).

¹ Dale A. Porter is Associate Parasitologist, Regional Animal Disease Research Laboratory, Auburn, Ala., Bureau of Animal Industry.

Although migration is common during development, the adult roundworms, or nematodes, to be discussed in this article occur in the digestive tract or lungs. Some roundworms, the lungworms and stomach worms, for example, are named for the location in which they are commonly found. The roundworms are elongated, cylindrical, unsegmented worms and may be characterized as threadlike or hairlike. The sexes are generally separate, and the males are usually smaller than the females.

Significant facts about the more common tapeworm and roundworm parasites of cattle and their control are discussed briefly in the following pages. The parasites of cattle are closely related to, and in some instances specifically identical with, those occurring in sheep, and from the standpoint of present knowledge more facts have been determined concerning parasitism in the latter host. Hence the reader should also refer to the article on Internal Parasites of Sheep and Goats, page 859.

CESTODA, OR TAPEWORMS

ADULT TAPEWORMS IN THE INTESTINE

Cattle in this country are known to harbor two species of tapeworms, *Moniezia benedeni* and *M. expansa*, both of which are common and sometimes serious pests of sheep also. The worms are whitish to yellowish in color and when mature may be several feet long and as much as three-fourths of an inch wide. The life history of *M. benedeni* is probably similar to that of *M. expansa*. The latter is transmitted by means of a tiny grass mite prevalent on pastures, particularly in damp areas. The mites eat the tapeworm eggs passed in the manure of cattle or sheep harboring the adult worms. The egg develops into a larval tapeworm within the mite, and when the mite is eaten by cattle the larval tapeworm is digested out and settles down in the small intestine, eventually reaching the adult stage (8, 17, 18).² As the worm grows, the terminal segments become filled with eggs that escape into the intestine and pass out in the droppings. The mature terminal segments, either individually or several together, are occasionally seen in the droppings of calves, particularly when they have diarrhea, and this aids in diagnosing the parasites.

It is generally believed that tapeworms do less damage in cattle than in sheep. Older animals are seldom affected, but young calves may harbor several of the worms, which may cause enough intestinal irritation to interfere with digestion and thus make the calves weak and unthrifty.

TAPEWORM CYSTS IN THE LIVER AND OTHER VISCERA

The hydatid (*Echinococcus araniulosus*) and the thin-necked bladder worm (*Cysticercus tenuicollis*) are the intermediate stages of two

² Italic numbers in parentheses refer to Literature Cited, p. 603.

tapeworms, *Taenia echinococcus* and *T. hydatigena*, which as adults are parasites in the intestines of dogs, wolves, and other canines. Closely related zoologically, their life histories are essentially similar. The canine hosts acquire the adult worms as a result of eating the cysts in dead animals or in offal from slaughtered animals. Cattle in turn acquire the larvae as a result of swallowing tapeworm eggs eliminated in the droppings of parasitized canines that have access to cattle pastures. The eggs hatch in the small intestine, and the embryo enters the intestinal wall, to be distributed by the blood stream to the preferred sites of development in the body. These bladder worms are found more frequently in sheep and swine than in cattle.

The hydatid forms fluid-filled, tumorlike cysts ranging up to several inches in diameter in the liver, lungs, and other organs. The bovine host is seldom suspected of harboring these parasites during life, although there may be pulmonary or digestive disturbances, depending upon the location of the cysts. Even the presence of large numbers of cysts which may have caused extensive tissue destruction is usually discovered only at slaughter.

The thin-necked bladder worm, *Cysticercus tenuicollis*, occurs embedded in the liver, attached to other abdominal organs, or free in the body cavity. The parasite looks like a sac full of clear liquid, usually about 1 inch in diameter. As in the case of the hydatid, the occurrence of this parasite in cattle cannot be diagnosed during life. A few bladder worms apparently have little or no effect on the host, and large numbers involving extensive liver damage by the immature larval form, as described in the case of sheep, have not been observed in cattle.

TAPEWORM CYSTS IN THE MUSCLES

The beef tapeworm (*Taenia saginata*), in the adult stage a parasite of man, occurs in cattle in the larval, or bladder worm, stage and is then known as *Cysticercus bovis*.

The condition in cattle caused by this worm is commonly referred to as beef measles. The cysticercus consists of a head, a neck, and a fluid-filled bladder within which the head and neck are inserted or sheathed. The worms appear as oval white vesicles about the size of a pea and occur throughout the muscles of the body but most frequently in the heart, muscles of mastication, diaphragm, and tongue. The life cycle involves an alternation between the two hosts, human beings and cattle. Infection of man is brought about by eating the bladder worm in raw or incompletely cooked beef; cattle in turn acquire the larvae as a result of swallowing the tapeworm eggs with drinking water or forage that has become contaminated with the excreta of the human tapeworm carrier. The small larvae hatch from the eggs in the stomach. Upon reaching the intestine they burrow into the gut wall and are carried by the blood stream, aided probably by their own movements, to various locations in the body. Development to the infective cystic stage has been estimated to take

from 7 to 18 weeks. Numerous cases of cysticercosis, or measles, detected under Federal meat-inspection procedure have been traced back to contacts with human carriers on farms and ranches.

Usually there are no definite symptoms associated with measles in cattle, and diagnosis depends on finding the cysts in the animals on post mortem examination. The economic importance of the parasite is in its relationship to human health. On account of the danger to human health from eating measly beef, precautions are taken to detect the parasite in beef carcasses through Federal and other equally thorough meat-inspection procedures.

NEMATODA, OR ROUNDWORMS

LUNGWORMS

Lungworms of cattle (*Dictyocaulus viviparus*) are white, threadlike worms 2 to 3 inches long. They inhabit chiefly the medium-sized and smaller bronchial tubes of the lungs. The female worms produce large numbers of eggs which usually hatch in the air passages, liberating larvae which are coughed up, swallowed, and eliminated in the feces. Sometimes the coughed-up eggs hatch in the stomach or intestines, but they often pass unhatched from the host, particularly when there is severe diarrhea.

Under favorable conditions the larvae eliminated with the feces develop to the infective stage in about a week. The infective larvae tend to migrate on grass in warm, wet weather and are taken in with the grass by grazing cattle. The course of development following ingestion of the larvae is believed to be similar to that of the lungworm of sheep (*Dictyocaulus filaria*). In this case the larvae penetrate the intestinal wall and reach the lymph glands, from which they are eventually carried to the lungs. The writer has observed that cattle lungworms mature in 3 to 4 weeks, at which time larvae appear in the feces, and that the worms are apparently capable of living 2 to 4 months within the host.

The worms and their eggs and larvae irritate the lung tissue, producing local inflammation which is manifested by the production of considerable frothy mucus. The extent of the damage to the functioning lung depends largely on the number of parasites present and the age and condition of the host; the parasites occur much more frequently in calves than in mature cattle. In light or moderate cases no symptoms are shown, with the possible exception of an occasional dry cough and poor condition. If the invasion is extensive there are frequent coughing spells, difficult breathing, and progressive weakness. The cases that usually prove fatal are those in which there is extensive involvement of the lungs, particularly as a result of the secondary invasion of bacteria. Such instances are characterized by shallow breathing with the mouth open and the tongue protruded (fig. 1). Death results from exhaustion or suffocation brought on by mechanical blocking of the air passages by worms and the accompanying discharge of mucus and pus.

STOMACH WORMS

Three species of roundworms (*Haemonchus contortus*, *Ostertagia ostertagi*, and *Trichostrongylus axei*) are common parasites in the abomasum, or fourth stomach, of cattle. Of these the first is the best known and is commonly referred to as the stomach worm or twisted wireworm.

The roundworm *Haemonchus contortus* is $\frac{1}{2}$ inch to $1\frac{1}{4}$ inches long and about as thick as an ordinary pin. The female worms produce large numbers of eggs, which pass out in the feces and hatch in a few hours under favorable conditions. The larvae, hatching from the egg, undergo two molts, reaching the infective stage in about 4 or 5 days.



FIGURE 1.—A 2-month-old calf with lungworm disease. Note the open mouth.

The infective larvae retain the last molt or skin and, thus ensheathed, are very resistant to cold and long periods of dryness. When there is rain or dew these larvae crawl up on blades of grass, with which they are swallowed by grazing cattle. The worms become mature in the stomach in 3 to 4 weeks.

Haemonchus contortus apparently affects cattle in the same way that it does sheep, although there may be some differences in the degree of cross transmission between the two hosts. According to Clunies Ross (5), lambs may be parasitized readily by *H. contortus* of either ovine (sheep) or bovine origin, whereas calves are parasitized with difficulty by *H. contortus* of bovine origin. As in the case of sheep, younger animals are the ones most seriously affected, although losses may occur occasionally among 3-year-olds (12). Among the common symptoms produced by this parasite are loss of flesh, general weakness, and anemia. The anemic condition, due to impoverishment of the

blood from the bloodsucking habit of the worms, may be recognized by the paleness of the skin and mucous membranes of the mouth and eyes and the edema, or watery swelling, known as bottle jaw, which often develops under the jaw (fig. 2). The latter condition is particularly noticeable after the animal has been driven or otherwise strenuously exercised. Diarrhea has also been considered as symptomatic, but the writer has not observed it in calves showing other clinical symptoms in experimental infections with stomach worms.

Ostertagia ostertagi, another parasite of the fourth stomach of cattle, is also occasionally found in sheep. A small hairlike worm, slightly

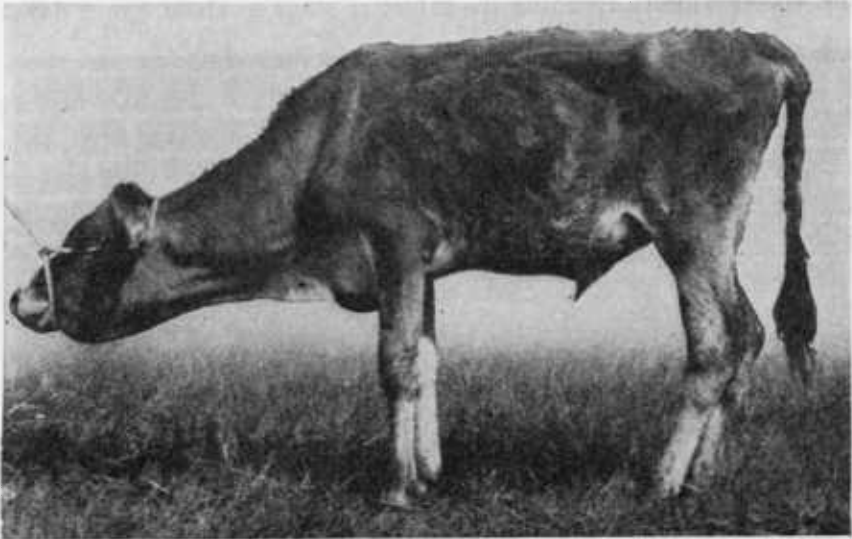


FIGURE 2.—A yearling steer with stomach worm disease. Note the submaxillary edema, or bottle jaw.

over one-fourth of an inch in length, it may often be overlooked. From what is known, its life history is similar to that of *Haemonchus contortus*. The infective larvae ingested with food reach the abomasum and there penetrate into the mucous membrane. Development to maturity takes place in small cystic nodules, or lumps, produced by the host in an attempt to overcome the invading larvae. Upon reaching maturity the adult worms escape into the stomach leaving the abandoned nodules to degenerate. The resulting patchy erosion may be detected as small white circumscribed areas on the stomach lining. The wall of the stomach may also be extremely thickened and swollen in severe cases.

In some sections of the United States, notably in the West, this parasite may replace *Haemonchus contortus* in importance. Stiles (15) considered it to be the chief factor in a severe outbreak of verminous disease in Texas cattle. Several outbreaks of verminous gastritis (inflammation of the stomach) due to this parasite have been de-

scribed. In outbreaks among yearling animals in which there were several deaths, the symptoms were emaciation, anemia, rough coat, and a diarrhea of varying intensity (1, 3). Submaxillary edema (bottle jaw) similar to that seen in cattle haemonchosis has also been reported.

Of the nematode parasites found in the stomachs of cattle, the third species, *Trichostrongylus axei*, is the least specific to a particular host. Large numbers of these parasites, which produce gastritis, have been observed in horses as well as cattle and other ruminants. Available evidence also indicates that this nematode may be transferred from one host species to another (4, 16, 20).

The parasites themselves are very slender and only about one-fifth of an inch or less in length. They are found on or in the mucous lining of the stomach, and detecting them usually depends on microscopical examination of scrapings made from the stomach lining. The details of the life history are not fully known, but it has been determined that the host is parasitized by swallowing the infective larvae that develop in the feces of other animals harboring the parasite (4).

Injuries to the bovine stomach consist of patchy gastritis in which the lining of the stomach is thickened and thrown into folds (2). Such symptoms as severe diarrhea and loss of condition have been associated with the presence of large numbers of these roundworms.

COOPERIDS

Three species of small nematodes (*Cooperia punctata*, *C. pectinata*, and *C. oncophora*), known collectively as cooperids, occur in cattle in the United States. *C. punctata* has a rather general distribution, having been encountered frequently in both the Northern and the Southern States. *C. pectinata* is prevalent mainly in the South, and *C. oncophora* is more prevalent in the North (6).

The adult worms are found on or imbedded in the mucous membrane, predominantly in the upper portion of the small intestine. Hairlike in thickness and about one-quarter inch long, the worms may be overlooked in a superficial examination. The development and transmission of these species are similar to those of the large stomach worm, *Haemonchus contortus*.

It is quite apparent that the cooperids are capable of producing extensive intestinal inflammation in calves. Descriptions given by Hung (7) and Dikmans (6) indicate that *Cooperia punctata* penetrates the intestinal mucous membrane and the layer beneath, producing a destructive inflammation that is particularly severe where the worms are numerous. Such lesions or tissue injuries appear on examination as accumulations of white or yellow cheesy material (11). Seriously affected animals have more or less persistent diarrhea and become emaciated and anemic as the disease progresses.

By reason of their widespread distribution and common occurrence these roundworms may be responsible for more cases of intestinal inflammation and unthriftiness in young cattle than is now generally recognized.

HOOKEWORMS

The cattle hookworm, called scientifically *Bunostomum phlebotomum*, belongs to the same family as the hookworms of other animals, including man, and shares the familial reputation of being a bloodsucker. A prevalent parasite of young cattle, this worm occurs normally in the upper small intestine, but it may invade the fourth stomach in small numbers and attach itself to the gastric mucous membrane. The worms attain a length of three-fourths of an inch to an inch and appear pinkish white in the intestine. The eggs of the female hookworm pass from the host in the droppings, hatch, and develop to the infective stage. According to Schwartz (14), they hatch in about 96 hours under laboratory conditions at a temperature of 70° to 80° F. The larvae undergo two molts, the third, or infective, stage completing a cycle of development that requires a minimum of 7 days. The infective larvae may be swallowed by cattle while grazing or penetrate the skin and develop to maturity upon reaching the intestine. The details of migration of the larvae following skin penetration are lacking. Probably the route is similar to that of the sheep hookworm (*B. trigonocephalum*), the larvae of which penetrate the skin, migrate to the lungs, presumably by way of the blood stream, and thence to the intestine by way of the windpipe, mouth, and gullet (10).

As is common with the hookworms, the adult is provided with mouth parts capable of attaching it to the intestinal mucous membrane. Aside from sucking blood directly from the host, the small lacerations produced by the mouth of the worm may be left bleeding as the worm moves from one place of attachment to another. This species, when present in large numbers, is capable of producing clinical symptoms similar to those produced by the stomach worm, *Haemonchus contortus*. According to Roberts (12), the disease runs a well-marked course of weakness, emaciation, intermittent diarrhea, and progressive anemia in which the red-cell count may be reduced as much as 75 percent in severe cases.

NODULAR WORMS

Unlike the intestinal worms discussed previously, the nodular worm, which is known as *Oesophagostomum radiatum*, is found in the large intestine and cecum. This worm is about five-eighths of an inch long and white in color. The eggs of the female are passed with the feces, and larvae are hatched that undergo some development on the ground similar to that of the stomach worm; *Haemonchus contortus*. The infective larvae swallowed by cattle enter the intestinal wall for a period of development and later migrate to the lumen of the intestine to develop to maturity.

The larval parasite and resulting secondary bacterial invasion cause the formation of nodules which, particularly after degeneration to a cheesy state, may be mistaken by inexperienced persons for the lesions of tuberculosis. Although the nodules may be encountered in the bovine omentum (a fold of the lining of the abdominal cavity),

they are usually restricted to the posterior (rear) portion of the small intestine and to the large intestine and cecum. These nodules are usually somewhat smaller than those caused by a related species, *Oesophagostomum columbianum*, in sheep, and the general effects of the parasite in cattle are believed to be somewhat less severe. (See Internal Parasites of Sheep and Goats, p. 859.) Such symptoms as anemia, scouring, and emaciation have been correlated with gross parasitism, and because of the permanent nature of the nodules, recovery may be slow.

GENERAL MEASURES FOR CONTROL

Control measures for any parasite depend on complete knowledge of its life history. Studies of the developmental stages usually reveal one in which the parasite is vulnerable to natural or man-made barriers and in which the life cycle may be broken. As research on parasites of cattle continues, control measures should be found which, if not capable of eradicating parasitism, certainly will be instrumental in reducing its toll.

Some general recommendations for the control of the more common tapeworm and roundworm parasites are given below.

Adult tapeworms in the intestine.—The transmission of these tapeworms (*Moniezia* species) involves certain free-living mites as intermediate hosts, but as yet too little is known about their life history or habits to make full recommendations for control. However, since young stock is most often affected, pastures known to be a source of infection should be closed to calves.

Tapeworm cysts of the liver and other viscera.—The control of hydatids and thin-necked bladder worms, both intermediate stages of adult tapeworms in canines, depends on some barrier between dogs and cattle. To effect this barrier, stray dogs and other canines should be kept off farms and suppressed by appropriate measures. Also, dogs belonging on the premises should be kept free of tapeworms by suitable remedies. (See Internal Parasites of Dogs and Cats, p. 1150.) As a precaution against infection of dogs with tapeworms, the viscera of slaughtered cattle, sheep, and hogs should be disposed of in such a manner as to be inaccessible to the dogs.

Tapeworm cysts of the muscles.—To prevent cattle from acquiring the cysticercus of the human tapeworm, *Taenia saginata*, care should be taken that human feces are not disposed of in such a manner as to contaminate the feed and drinking water of the cattle. Prevention of tapeworm in the human being is simple and effective: Cook beef thoroughly.

Roundworm parasites.—In view of the similarity in the development of the free-living stages of the commonly important gastrointestinal roundworms and lungworms of cattle, preventive measures are in general applicable for all species concerned. Any control measures should be set up primarily to reduce the chances that calves and yearlings will become seriously parasitized, since young cattle are the most susceptible.

As moisture favors the development of the eggs and larvae of

roundworms, well-drained pastures are preferable, and low, wet areas should be avoided until they are drained. Drinking water should be supplied from wells or flowing streams, preferably in troughs raised above the ground. Pastures that it is impractical to drain should be used only for mature cattle.

Pastures should not be overstocked, and rotation, as often as available forage permits, is highly desirable, since free-living stages of the parasites in a contaminated field will largely succumb in the absence, for a sufficient time, of susceptible hosts.

Young animals being most susceptible to parasitism, calves should be kept as much as possible away from the older stock and the contaminated pastures and quarters where the latter have been confined. As a precaution against further spread of parasitism, any affected cattle should be isolated from the herd for special treatment. Sanitation and good feeding will sometimes stop losses from parasitism even if no medicinal treatment is given.

MEDICINAL TREATMENT

Owing to the similarity of the effects of parasitism in cattle and in sheep the medicinal control of the tapeworm and roundworm parasites of cattle has followed closely the treatments recommended for sheep. In few instances, however, has the efficacy of the drugs been determined by critical tests on cattle; recommendations for their use are based largely on clinical data or the performance of the drugs on related worms in sheep.

A 1-percent solution of copper sulfate has been used for the control of the stomach worm *Haemonchus contortus*. This solution is given as a drench in doses of the following sizes: Calves, 3½ to 4 fluid ounces; yearlings, 6 fluid ounces; 2-year-old and older cattle, 12 to 16 fluid ounces. The addition of 1 ounce of 40-percent nicotine sulfate to a gallon of 1-percent copper sulfate administered in doses of the same sizes as above has also been recommended as a treatment for stomach worms, hookworms, and tapeworms (*Moniezia* species). Mönnig (9) reports that a mixture composed of 30 cubic centimeters of 40-percent nicotine sulfate and 30 grams of copper sulfate in 1,800 cubic centimeters of water has given satisfactory results against the tapeworms (*Moniezia*) and stomach worms (*Haemonchus*) in cattle in the field. The mixture is given at the rate of 30 cubic centimeters to each 50 pounds of live weight, with a maximum of 90 cubic centimeters for animals under 2 years of age, and 120 to 150 cubic centimeters, according to size, for those over 2 years old. Crude castor oil is recommended as a purgative to follow this treatment for tapeworms.

Some investigators recommend tetrachlorethylene as a medicinal control for stomach worms, hookworms, and the small intestinal roundworms (*Cooperia* species). This drug may be administered in capsules or as a drench in an emulsion consisting of equal parts of the drug and mineral oil. The dosage of tetrachlorethylene recommended is 10 to 15 cubic centimeters for calves 2 to 4 months old and up to 25 to 30 cubic centimeters for animals 12 to 18 months old (13).

The tetraethlorethylene emulsion may be given immediately following the introduction of about 2 cubic centimeters of a 5-percent copper sulfate solution into the mouth (2). Recent critical tests (19) supplemented by clinical data indicate that phenothiazine may have considerable promise as an anthelmintic for the removal of stomach worms, hookworms, and nodular worms. On the basis of available data, a dose of 20 grams per 100 pounds of live weight, with a maximum individual dose of 60 grams, administered in capsules, is suggested.

Treatment for parasites outside the gastrointestinal tract is unsuccessful. There are no medicinal agents for the removal of tapeworm cysts, and although various chemicals have been administered by inhalation or injection into the windpipe for the removal of lungworms, none has shown effectiveness. Lungworm cases are probably best treated by removing the animals from pasture to clean sanitary quarters and supplying liberal quantities of feed.

While parasitism may be suspected in young cattle in unthrifty condition, malnutrition or other conditions may be present, if not actually responsible. Animals in a weakened condition may react unfavorably to medication, and it is therefore advisable to obtain competent diagnosis and advice before resorting to treatment.

In treating young cattle for parasites it is advisable to treat not only the animals that are seriously affected but also the rest of the herd, since any parasites remaining in the herd become a source of reinfection. Following treatment the animals should if possible be removed to fresh pastures.

LITERATURE CITED

- (1) ACKERT, JAMES E., and MULDOON, WILLIAM E.
1920. STRONGYLOSIS (OSTERTAGIA) IN CATTLE. *Amer. Vet. Med. Assoc. Jour.* 58: 138-146, illus.
- (2) BAKER, DONALD W.
1939. A NEW SYSTEM OF ANTHELMINTIC CONTROL FOR GASTRO-INTESTINAL PARASITES OF RUMINANTS. *Cornell Vet.* 29: 192-197, illus.
- (3) BARGER, E. H.
1927. OSTERTAGIA OSTERTAGI IN CALIFORNIA CATTLE, WITH COPPER SULPHATE AN APPARENTLY SUCCESSFUL THERAPEUTIC. *Amer. Vet. Med. Assoc. Jour.* 71: 560-567, illus..
- (4) BRITTON, JOHN W.
1939. TRICHOSTRONGYLOSIS IN EQUINES. *Cornell Vet.* 29: 322-330.
- (5) CLUNIES ROSS, I.
1931. THE HOST SPECIFICITY OF HAEMONCHUS CONTORTUS OF SHEEP AND CATTLE. *Austral. Jour. Expt. Biol. and Med. Sci.* 8: 217-224.
- (6) DIKMANS, G.
1939. PARASITIC ENTERITIS IN CALVES. *Vet. Med.* 34: 28-30, illus.
- (7) HUNG, SEE-LU.
1926. THE PATHOLOGY OF COOPERIA PUNCTATA INFESTATION IN CALVES. *North Amer. Vet.* 7 (3): 33-36, illus.
- (8) KRULL, WENDELL H.
1939. ON THE LIFE HISTORY OF MONIEZIA EXPANSA AND CITOTAEINIA SP. (CESTODA: ANOPLOCEPHALIDAE). *Helminthol. Soc. Wash. Proc.* 6: 10-11.
- (9) MÖNNIG, H. O.
1937. ON THE TOXICITY OF NICOTINE FOR SHEEP AND THE USE OF THE NICOTINE-BLUESTONE DRENCH FOR WORMS IN RUMINANTS. *Rev. de Med. Trop. y Parasitol.* 3: 3-10.

- (10) ORTLEPP, R. J.
1939. OBSERVATIONS ON THE LIFE-HISTORY OF BUNOSTOMUM TRIGONOCEPHALUM, A HOOKWORM OF SHEEP AND GOATS. Onderstepoort Jour. Vet. Sci. and Anim. Indus. 12: 305-318, illus.
- (11) RANSOM, [B. H.]
1920. INTESTINAL LESIONS IN CALVES DUE TO COOPERIA PUNCTATA. Jour. Parasitol. 7: 96.
- (12) ROBERTS, F. H. S.
1939. THE GASTRO-INTESTINAL HELMINTHS OF CATTLE IN QUEENSLAND: THEIR DISTRIBUTION AND PATHOGENIC IMPORTANCE. Roy. Soc. Queensland Proc. (1938) 50: 46-54, illus.
- (13) _____
1940. PARASITIC WORM DISEASES OF CATTLE. Queensland Dept. Agr. and Stock, Div. Ent. and Plant Pathol. Advisory Leaflet 26, 20 pp., illus.
- (14) SCHWARTZ, BENJAMIN.
1924. PREPARASITIC STAGES IN THE LIFE HISTORY OF THE CATTLE HOOKWORM (BUNOSTOMUM PHLEBOTOMUM). Jour. Agr. Res. 29: 451-458, illus.
- (15) STILES, CH. WARDELL.
1901. VERMINOUS DISEASES OF CATTLE, SHEEP, AND GOATS IN TEXAS. U. S. Dept. Agr., Bur. Anim. Indus., Ann. Rpt. 17 (1900): 356-379.
- (16) STOLL, NORMAN R.
1936. OBSERVATIONS ON CATTLE NEMATODE INFECTIONS, WITH A DEMONSTRATION OF THEIR SECONDARY TRANSMISSION TO GRAZING SHEEP. Jour. Parasitol. 22: 386-407.
- (17) _____
1938. TAPEWORM STUDIES VII. VARIATION IN PASTURE INFESTATION WITH M. EXPANSA. Jour. Parasitol. 24: 527-545, illus.
- (18) STUNKARD, HORACE W.
1937. THE LIFE CYCLE OF MONIEZIA EXPANSA. Science 86: 312.
- (19) SWANSON, L. E., PORTER, D. A., and CONNELLY, J. W.
1940. EFFICACY OF NONCONDITIONAL PHENOTHIAZINE IN REMOVING WORMS FROM ALIMENTARY CANAL OF CATTLE. Amer. Vet. Med. Assoc. Jour. 96: 704-707.
- (20) TAYLOR, E. L.
1937. PARASITIC GASTRITIS. THE TRANSFERENCE OF THE CAUSATIVE HELMINTHS FROM SHEEP TO CATTLE. Vet. Jour. 93: 353-355.

At the time this book went to press, the drugs and other materials mentioned in various articles—chiefly as disinfectants, insecticides, and anthelmintics—were still available for veterinary and medical use. Under war conditions, however, it is possible that some of these materials may become scarce or unavailable. In that case, the reader should obtain professional advice from the Department of Agriculture, the State experiment station, a local veterinarian, or the county agent as to available substitutes.