Diagnosis and treatment of internal parasites / by Maurice C. Hall.

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HALL

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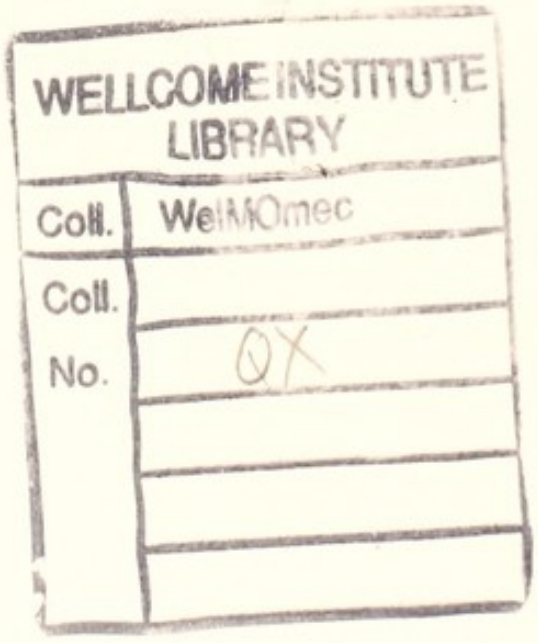

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The Laboratory Diagnosis and the Treatment of Internal Parasitic Infestation

Collecting and Examining Parasites

The collection of parasites calls for certain personal equipment and a limited amount of apparatus. Some collectors have a highly developed personal equipment. It consists in: 1, an intense and persistent interest in parasites; 2, a tremendous curiosity on the subject, which leads one to scrutinize every suspicious object as a possible parasite; 3, an equal amount of pertinacity, which impels the investigation of these objects until they are definitely proven parasitic or non-parasitic and not merely probably one thing or another; 4, a faith and conviction that there are parasites present; 5, a thoroughness which lets no parasite escape. To collect parasites one should be in the mood to collect parasites. Given this, one needs only keen eyesight, a small amount of apparatus and a system for examination of the host animal.

Search Everywhere

As regards a system for examining animals for parasites, one must know where to look. So far as time and other circumstances permit, look everywhere. Examine all pathological conditions as possibly of parasitic nature. Examine all cavities, large and small. Assume that the digestive tract always has parasites; that the respitory and circulatory systems sometimes harbor parasites, and that the skeletal, muscular, nervous and reproductive systems may harbor parasites at times.

Superficial Examination Not Sufficient.

In examining an animal for parasites, the usual postmortem examination instruments, knives, scalpels, forceps, etc., are necessary. In addition an enterotome is essential; it is the one instrument which the parasitologist finds indispensable. The intestine is such an important site of infestation for parasites that the enterotome with

the guarded point saves a large aggregate amount of time over ordinary scissors or a knife in opening intestines. Too many routine postmortem examinations fail to take into consideration the lumen and inner lining of the stomach and intestines. The condition of the mucosa and the presence or absence of parasites are guessed at from a superficial observation of the serous coat. This method affords inferior evidence as to conditions present and the parasitologist cannot use such a method in examining animals for parasites. It is true that ascarids and other worms may at times be detected in this manner, but it is also true that large numbers of worms cannot be detected in this manner. For all-around use, an enterotome should have long, comparatively narrow blades with a guard of moderate size on one blade. Such an enterotome can be used on anything from the size of a chicken to that of a horse.

Handling Specimens Collected

A few tall jars, some glass dishes and an ample supply of running water are a great aid in collecting certain kinds of parasites. Rubber gloves may be used if desired; they afford protection from infection and also from undesirable odors on the hands. In the postmortem examination of the dog, cat, swine or animals of similar size, it is advisable to put the stomach into one jar of water, or, better, physiologic saline solution, the small intestine into another jar, the cecum into another and the colon and rectum into another. Slit each of these organs, wash the contents into the jar, scraping off adherent material from the organ, especially its mucosa, and then discard it. After the contents of the jar have sedimented, decant the supernatant fluid down to the mass of intestinal contents at the bottom of the jar, getting rid of the soluble coloring matter and the floating flocculent matter. Worms will remain in the heavier ingesta at the bottom. Add fresh water or saline and again decant, repeating this process until the supernatant fluid over the intestinal contents is clear. It is advisable to let the fresh water trickle down the sides of the jar in order not to form bubbles which may carry parasites to the surface. In fact all matter flowing out of the jar in the process of decanting should be scrutinized for possible parasites sustained by air bubbles, straw, etc.

When the supernatant fluid is clear, the material in the jar should be agitated in order to stir up the intestinal contents and a small amount

of this material should be poured into a glass dish and examined over a dark background, the dish itself being in a good light. The best background is that afforded by a shadowy floor when the dish is held at the level of the laboratory table. Parasites are visible as distinct objects of definite outline, frequently white or yellowish, though sometimes red or motley colored, and usually actively motile. They may be picked out with a dissecting needle, forceps, or, if very small, with a pipette. Where such objects appear, but are not definitely recognizable, the use of a small hand lens, with a magnification of 6 to 12 diameters, will usually aid in determining their nature. Failing this, one must resort to the use of the dissecting microscope, binocular or ordinary compound microscope.

Examination of Stomach Contents of Large Animals

With such large animals as horses, cattle and sheep, it is seldom necessary or feasible to wash and decant the stomach contents. The stomach of the horse may be slit and the gastric mucosa carefully examined after the contents have been rolled out in such a way as to keep them together as much as possible. An examination of the exterior of this mass of contents, the part which has been in contact with the stomach wall, will usually show many more parasites than the interior of the mass, or the part which occupied the central portion of the gastric lumen. The rumen, reticulum and omasum may be slit and examined in a similar manner in the case of ruminants, but the fourth stomach or abomasum should be washed and decanted. Parasites are occasionally present in the first three stomachs. They are almost always present in the fourth stomach.

The Intestines of a Horse Rarely Washed

The small intestine of the horse is rarely washed and examined for parasites and the large intestine cannot be satisfactorily handled in this manner. In the latter, the examination of the intestinal wall and of the contents in contact with the wall indicate well the nature of the parasites present, and where it is desired to obtain all the parasites present, so far as possible, as is the case in testing anthel-

mintics, the contents may be rolled into balls, squeezed to remove the excess water, and carefully picked apart by hand.

It is, of course, unnecessary to wash and decant in the case of the esophagus, since this organ is devoid of a constant content. The esophagus may be examined by stretching it between the hands and holding it up to the light in order to detect such worms as the gullet worms, the latter occurring in horses, cattle, sheep and swine. They may be detected under the mucosa of the tongue and pharynx, also, in some cases.

Examination of the Lungs.

The examination of the lungs for parasites may call for the use of both the enterotome and the knife. Cysts, such as those of the lung fluke, Paragonimus, may be sought for and investigated with the aid of the knife, but the nematodes known as lungworms, much commoner parasites, are best sought for with the aid of an enterotome. The entertome facilitates slitting the trachea, bronchi and smaller air tubes and these should be slit as far as possible, especially where the pulmonary pleura shows any evidence of inflamation, as the worms are frequently present only in the smaller tubes when present in small numbers.

Occasionally even the trained pathologist will neglect the opening of the smaller air tubes and will search in vain for evidence of tuberculosis or other bacterial disease to account for symptoms and lesions due to worms which only need to be loked for to be found. Some of the smallest lungworms, such as some species from sheep, are difficult to detect and it may facilitate the search for these to put portions of the lung showing inflammation into water and look closely for worms floating out from the tissue.

Sometimes microscopic examination of stained slides is necessary to demonstrate the small lungworms present. Numerous petechiae suggest the presence of larval ascarids or other worms; these petechial areas may be examined in press preparations under the microscope to determine the presence or absence of these worms.

The use of two metal frames, connected by screws for pressing two heavy glass slides together, facilitates the examination of such specimens, but lacking such apparatus two ordinary glass slides may be utilized and held together by rubber bands if desired. All lesions

that could possibly be parasitic, and there is a wide range of such lesions, should be examined for parasites.

Excretory System

The excretory system may harbor such parasites as kidney worms in swine and the giant kidney worm in dogs. Larval worms may also occur in the kidneys, but these can only be detected or suspected on the evidence of lesions produced by them.

Circulatory System

In the circulatory system parasites may be expected in the anterior mesenteric artery of horses in the large majority of cases (Strongylus vulgaris in verminous aneurisms) and in the right heart and pulmonary artery of many dogs in parts of the southern United States. A number of parasitic worms use the blood stream as a distributing current during part of their life history and the blood may be examined for such forms by laking with three percent glacial acetic acid and centrifuging, the sediment being examined microscopically for worms.

Skeletal, Muscular and Nervous Systems

Parasites in the skeletal, muscular, nervous and reproductive systems are not very common, but such parasites as hydatids in bones, trichinae in swine musculature, the gid bladderworm in the brain of sheep, and flukes and roundworms in the oviduct of chickens warrant us in remembering the possibility of such occurences and in investigating wherever symptoms or lesions suggest the advisability of so doing.

Examination of the Specimen

The parasites collected should be washed in physiologic saline solution to remove mucus and other adherent material, otherwise this material will interfere with proper fixation and frequently appear on mounted material at points where it obscures important anatomical details. After washing, nematodes should be transferred, whenever possible, to hot 70 percent alcohol, in which they usually straighten out in a satisfactory position for subsequent examination. Tapeworms and flukes are killed in a very satisfactory manner in equal parts of 70 percent alcohol and a saturated aqueous solution of corrosive sublimate, to which is added one percent glacial acetic acid. This may be used cold, or better, at a temperature of 70 to 80° C.

(158°-176° F.). Allow this mixture to act for 10 to 20 minutes. Subsequently these worms should be washed and then put in a tincture of iodin to remove the excess of corrosive sublimate. For collecting specimens in the field or wherever there are no laboratory facilities, a weak formalin solution, one to two percent, is fairly satisfactory.

Nematodes may be examined in physiologic saline while yet alive or cleared for study by transfer from 70 percent alcohol to the same strength of alcohol containing 5 to 10 percent glycerin. This mixture and the contained worms may then be placed in an incubator or paraffine oven and kept there until the evaporation of the alcohol leaves the specimens in glycerin. By this time the specimen is usually quite clear and the transfer to glycerin is sufficiently slow to prevent the distortion of the specimens by osmosis. The worms may then be permanently mounted in glycerin or glycerin jelly. Some nematodes, especially small ones, may be transferred to glycerin jelly directly from 70 percent alcohol without sufficient distortion to make an ordinary identification at all difficult, but large worms are usually much distorted by such a transfer. Another clearing agent consists of 20 parts of absolute alcohol and 80 parts of carbolic acid. Nematodes are rarely stained for examination by most workers, as they are not amenable to most stains, but gentian violet is fairly penetrating and may be used to bring out many interesting details of structure. Haematoxylin is also used at times and gives a good picture. Occasionally nematodes are dehydrated, cleared and mounted in balsam, but this often makes them too transparent for some purposes and simpler and quicker methods are usually quite as satisfactory or more satisfactory.

Tapeworms and flukes are usually stained, dehydrated, cleared and mounted in balsam for study and identification. Tapeworm scolices or heads may be mounted in glycerin, glycerin jelly or similar media for the examination of the hooks, and gravid segments are sometimes similarly mounted for the purpose of examining the eggs.

Probably there is no field in which the veterinarian can find more new scientific facts with more ease than in the field of parasitology. A number of interesting parasites of the domesticated animals

were originally described from the United States and some of the records of rare parasites are from this country.

Undoubtedly there are other undescribed parasites and unrecorded occurrences of rare parasites which would be brought to light if more veterinarians took an active interest in the subject of parasitology. It should be an especially interesting field to the young man who still has energy to expend on postmortem examinations and who has not yet grown rusty in regard to what he learned of parasitology in college.

Examining Feces for Parasites and Parasite Eggs

THE diagnosis of parasitic infestation of the stomach and intestines, and to some extent infestation of the liver, respiratory tract and some other portions of the body, is largely based on miscroscopic, and to a lesser extent on macroscopic, examination of the feces. These diagnosis are, for the most part, quite positive and dependable and are not difficult to make. They call for the use of a microscope, a somewhat expensive piece of apparatus, but the present day veterinary practitioner who is using modern laboratory methods needs a microscope as an essential part of his equipment for a large amount of work other than diagnosing parasitic infestations. Aside from a microscope, slides and cover glasses, very little apparatus is necessary for examining feces for evidences of parasitism, though if one has much work of this sort to do, a slight increase in the amount of apparatus and a somewhat more elaborate technic will save time, nervous energy and eyestrain.

Materials Sometimes Deceptive

It is a common thing for the owners of livestock to find worms passed in the feces of their animals and to bring them to the veterinarian for examination. Specimens of this sort are frequently easy to determine and a diagnosis of a definite sort follows immediately from the identification. Sometimes the specimens brought in for identification are spurious parasites, material of various sorts which is not parasitic, but which deceives the client and may at times deceive the veterinarian. A proper technic for the examination of feces where parasitism is suspected will usually save the veterinarian from error along this line.

Technic of Fecal Examination

It is intended here to outline for the most part only the principles underlying the technic used in examining feces. As a rule everyone

develops his own technic, this being largely a matter of personal preferences and local conditions. The same result can doubtless be obtained by any one of numerous variations in technic, and results are what count.

Stirring With Stick May Fail

The most simple and direct method of examining feces macroscopically for evidence of parasitism consists in poking about in the manure with a stick or something of the sort for objects resembling worms. It is what the farmer usually does and what the veterinarian not uncommonly does. It must be admitted that occasionally one finds parasites in feces in this manner, but it must also be admitted that this is the least satisfactory method of examining feces. Parasites embedded in feces are easily overlooked and non-parasitic objects smeared with feces are easily mistaken for parasites. It is possible for horse manure to contain hundreds of worms and not one worm to be found by such technic.

Technic Must Conform to Given Specimens

To determine whether worms are present in feces, information which may be desired after the administration of an anthelmintic, one should adapt one's technic to the nature of the feces. The physician has a comparatively simple task in examining human feces, since these feces are made up mostly of finely comminuted material and a very small amount of large coarse material. The veterinarian has no such simple task. Dog and cat feces are somewhat comparable to human feces, but they contain more coarse material in many cases. Swine feces usually contain yet larger amounts of coarse material. Sheep and goat feces are commonly in hard pellets which must be broken up to permit of an examination of the comminuted vegetable material composing these pellets. Cow manure is usually soft enough to be easily examined, but its bulk is a disadvantage. Horse manure contains much coarse vegetable material and the manure for one day is bulky enough to require about a day's work to examine it carefully and completely for worms.

Screening a Great Help

Wherever it is feasible to screen feces to examine them for parasites, screening is a great help. The feces of the dog, cat and pig may be broken up in water and screened without difficulty. Sheep and goat feces are much more difficult to handle in this way, though they can be screened to advantage in looking for parasites. Cow manure is easily screened, but its bulk makes the examination of the manure for one day a task. Horse manure is too coarse to screen successfully in the amounts passed in one day and must be examined by being carefully picked apart by hand. Wherever screens may be used, the nature of the screen to be used depends on circumstances.

Where few fecal examinations are made and little apparatus is available, a piece of cheesecloth may be stretched over hoops or a bucket top to make a screen. Where fecal examinations are a routine matter, wire screens, such as copper or brass screens, of assorted sizes, from 6 to 100 mesh apertures to the inch, are of value. After the feces have been broken up thoroughly by soaking in water and shaking, they are poured through the screen or screens and each screen then put in a glass dish containing water and examined for parasites. The material on the screen may be rinsed off into this glass dish and examined for worms or other parasites present.

Examination for Parasite Eggs

Where parasite eggs are sought for by microscopic examination, the simplest technic is the so-called smear method. A bit of feces is taken on a match, tooth-pick or stirring rod, rubbed to a uniform smear in a little water on a slide, covered with a cover glass and examined under a microscope. It will afford satisfactory evidence as to the presence of parasite eggs provided there are numerous eggs present in the feces. For detecting gross infestations this method may be entirely satisfactory in some circumstances. It is not a delicate method and can not be depended on to detect light infestations. Its results become increasingly dependable in proportion to the number of slides made and examined from a given fecal sample, but the length of time involved in examining such preparations makes it

far more profitable to put some of this time on the technical manipulation of the feces before making the slide to be examined.

A Simple Technic

The technical manipulation necessary to prepare more satisfactory slides for examining is designed to concentrate the parasite eggs originally scattered throughout the feces by removing that part of the feces which can readily be separated on the basis of differences in size, specific gravity, solubility, etc., in other words on the basis of physical and chemical differences. A simple technic that will give a high degree of concentration is as follows: Feces are broken up, screened through a set of screens placed in a rack with the coarse screens at the top and the finer ones at the bottom, the material passing through all the screens being caught in a suitable tray or dish; after standing a minute or so, the top half of this material is decanted and replaced by clean water; this process is repeated every minute until the soluble coloring matter and floating flocculent matter is poured away and the water stands clear on the sediment at the bottom; the water is then decanted until only a little is left on the sediment and this is shaken up and poured into a centrifuge tube till the tube is full; the tube is then set in a rack until ready to be examined.

In the course of this manipulation, all fecal matter too coarse to pass through a screen of 100 apertures to the inch, which will allow the passage of the largest parasite eggs one need consider in work of this sort, has been eliminated by the screens; the soluble coloring matter and floating flocculent material which would obscure the view of the eggs on the slide have been eliminated by washing and sedimenting; what is left consists of parasite eggs and other material of approximately the same size as the eggs or smaller, and material approximately as heavy or heavier.

When there is a bottom sediment evidently composed of sand in the tray or dish used to catch the feces passing through the screen, this should be allowed to stay in the dish and not rinsed into the

test tube as the eggs are lighter and will be on top of such sediment. The technic given in this discussion causes a high degree of concentration of parasite eggs and is applicable to feces from a wide range of host animals, from canary birds to elephants.

Standard Methods Apply Only to Human Feces

There are many published methods for examining feces for parasite eggs, but most of them are intended only for human feces, which is a very special case and some of them only for hookworm eggs, which again is a very special case. They are more or less elaborate, though sometimes very useful within the range of their applicability. For the purposes of the veterinarian the simpler technic given here and intended for feces of any sort and the detection of parasite eggs of any sort is recommended.

In examining feces under the microscope for parasite eggs, one must use care not to mistake plant spores, plant hairs, etc., for eggs and worms. To this end it is necessary to consult the available text and reference books in regard to the eggs of the various parasites of the host animal up for examination. Unfortunately, the existing books do not lay much emphasis on egg sizes and shapes in all instances and it is sometimes difficult to get the desired information.

The courses in parasitology in our veterinary colleges should contain enough work in fecal examination to make students reasonably familiar with the technic and the interpretation of the slides prepared, so that eggs found will at least be recognizable in a general way to students and to practitioners thus properly trained.

Failure to find eggs in feces with any technic whatsoever is not conclusive proof that no worms are present. In very light infestations the few eggs present in feces may not occur in the preparations examined; where only male nematodes are present there will be no eggs in the feces; where only larvae or young worms are present there will be no eggs; and egg production may be interrupted or terminated by old age, anthelmintics or accident.

The Eggs and Larvae of Dog, Cat and Fox Parasites

IN previous pages, the subject of examining feces for parasites and parasite eggs has been discussed. It now seems advisable to follow this with some descriptions with illustrations of the parasite eggs present in the case of the dog, cat and fox. There has been some demand for something of the sort on the part of veterinarians, and in view of the scarcity of illustrations covering this point in text-books and the fact that the available illustrations are scattered through numerous publications largely inaccessible to the practitioner, there is evidently some reason for the demand. Strange as it may

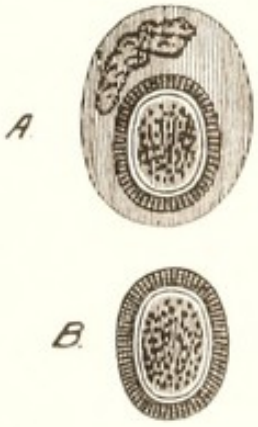

Fig. 1. *Taenia pisiformis*. A, egg surrounded by vitelline membrane containing vitelline masses. B, embryophore. Enlarged. From Railliet, 1893.

seem, the eggs of some of the commonest parasites have been figured but very seldom, presumably on the assumption that everyone interested in them is familiar with them, which is not a safe assumption. Some of the available figures are not very satisfactory, but material for new illustrations is not always available in these cases, and as the existing illustrations serve the purpose of at least indicating something of the appearance of the egg in question, they have been copied here.

A number of the figures are taken from Railliet's Traité de zoologie médicale, a work which has been for almost thirty years the most satisfactory reference book of veterinary parasitology. It is a matter for regret that this splendid work has never been issued in revised editions and brought up to date. At the present time it is almost impossible to purchase copies of the sole edition printed.

In examining the feces of dogs, cats and foxes for parasite eggs, there are certain eggs which are very commonly present, and for this reason these eggs are figured here. However, it is the uncommon

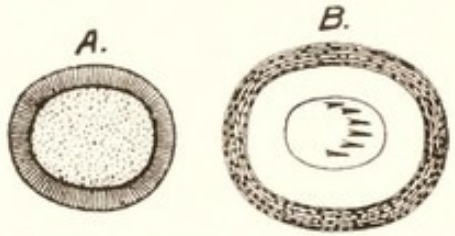

Fig. 2. *Taenia hydatigena*. A, egg as seen mounted in glycerine. B, egg after treatment with a concentrated potash solution. x 350. From Railliet, 1893, after Laboulbène.

thing which is most perplexing, and for this reason the eggs of some of the rarer parasites are also figured. Among the commoner species present are tapeworms of the genera Taenia and Dipylidium and nematodes of the genera Belascaris, Toxascaris, Ancylostoma and Trichuris.

In the genus Taenia, the egg forms with a thin shell, with or without filaments, and the embryo, or onchosphere, lies inside of this

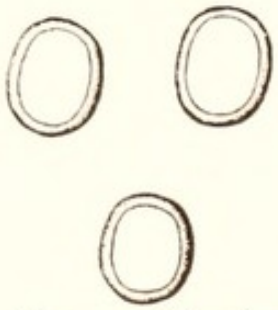

Fig. 3. *Echinococcus granulosus*. Eggs. x 245. From Blanchard, 1889, after Krabbe.

enclosed in a thick, radially striate shell called the embryophore. As found in the feces only the embryophore and the contained embryo, or onchosphere, are present as a rule. This embryophore is commonly termed the egg and is so termed in this paper. The contained embryo is armed with six small hooks which may be seen without difficulty under the ordinary powers of the microscope. The

eggs of tapeworms of the genera Multiceps and Echinococcus are quite similar in structure. In view of the overlapping of the egg sizes of tapeworms in this group, it is not usually feasible to make a definite diagnosis in regard to the species of tapeworm present, but

Fig. 4. *Dipylidium caninum*. Egg capsule. Enlarged. From Stiles, 1903.

such a diagnosis is usually unnecessary anyway. The following figures cover briefly the eggs of some of the dog, cat and fox tapeworms.

Taenia taeniaeformis (T. crassicollis) of cats, spherical, 31 to 37 microns in diameter; T. pisiformis (T. serrata) (Fig. 1) of dogs and

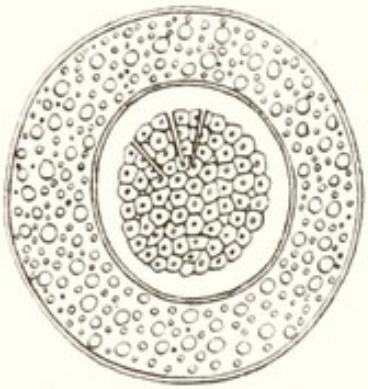

Fig. 5. *Dipylidium caninum*. Egg. Magnified. From Railliet, 1893, after Moniez.

foxes, elliptical, 37 by 34 microns; T. hydatigena (T. marginata) (Fig. 2) of dogs, elliptical, 38 to 39 microns by 34 to 35 microns; T. ovis of dogs, 30 to 34 microns by 24 to 28 microns; Multiceps multiceps (T. coenurus) of dogs, spherical, 29 to 38 microns; M. serialis

Fig. 6. *Mesocestoides lineatus*. Eggs. x 300. From Railliet, 1893.

(T. serialis) of dogs, elliptical, 31 to 34 microns by 29 to 30 microns; Echinococcus granulosus (T. echinococcus) (Fig. 3) of dogs and cats, elliptical, 32 to 36 microns by 25 to 30 microns.

The eggs of Dipylidium have two thin shells and are contained in

egg capsules formed by the breaking up of the reticular uterus. The number of eggs in a capsule varies with different species and may vary in one species. In the case of worms of this genus, one may find, in the feces of infested animals, segments, egg capsules or individual eggs. In D. caninum of dogs and cats, the egg capsule (Fig. 4) may contain 5 to 20 or more eggs, the egg (Fig. 5) being spherical, 43 to 54 microns in diameter and with an onchosphere 25 to 36 microns in diameter. In D. sexcoronatum of dogs and cats, the egg capsule may

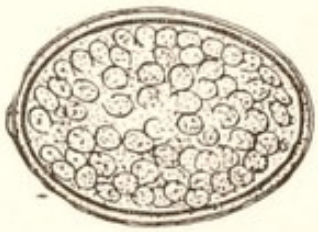

Fig. 7. *Diphyllobothrium latum.* Egg. x 680. From Magath, 1919.

contain 2 to 15 eggs, the eggs being spherical and 21 microns in diameter.

The eggs of tapeworms of the genus Mesocestoides are ovoid and have two very thin shells. The egg of M. lineatus (Fig. 6), which appears to be identical with M. litteratus, of dogs, cats and foxes, is 40 to 60 microns long by 35 to 43 microns wide.

The eggs of Diphyllobothrium (Dibothriocephalus or Bothriocephalus) are elliptical and provided with a small operculum or lid at

Fig. 8. *Opisthorchis pseudofelineus.* Egg. Enlarged. From Barker, 1911.

one end. The egg of D. latum (Fig. 7) of dogs, cats and foxes is 68 to 71 microns long by 44 to 45 microns wide, according to texts. Magath finds a range of 55 to 76 microns in length by 41 to 56 microns in width. In general the figures given here for egg sizes are those given in texts. As a matter of fact, careful measurement of a large number of eggs will usually show some eggs which lie outside of the range of measurement given.

Fluke eggs are usually more or less oval in shape, with an

operculum or lid at one end. Opisthorchis pseudofelineus (Fig. 8) of cats has an egg 29 to 36 microns long by 14 to 16 microns wide.

Nematode eggs are very variable in shape and in the amount of development at the time they are deposited. Some of the more common are discussed below.

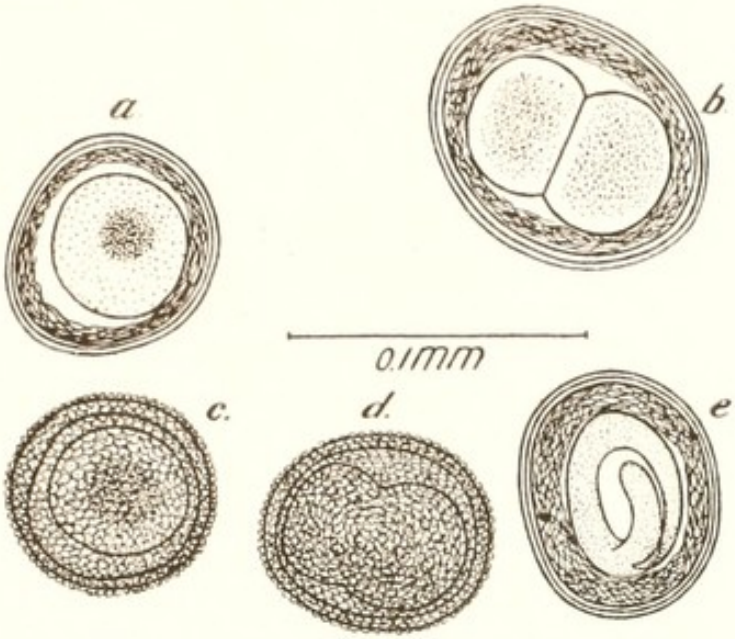

Fig. 9. a, b, *Toxascaris limbata*. Eggs. e, With developed embryo.
c, d, *Belascaris marginata*. Eggs. Enlarged as indicated. From Wigdor, 1918.

In the genus Belascaris, the eggs are more or less globular to elliptical, with a thin pitted shell. In B. marginata of the dog, the eggs (Fig. 9) are 72 to 104 microns long by 50 to 78 microns wide. In B. mystax of the cat, the eggs are more or less oval and 65 to 75 microns long.

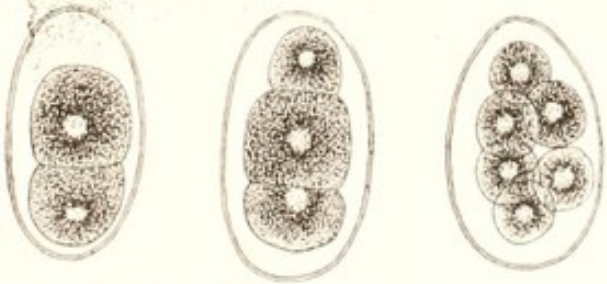

Fig. 10. *Ancylostoma caninum*. Eggs in various stages of development. x 300.
From Railliet, 1893.

In the genus Toxascaris, the eggs are ellipsoidal, clear and smooth in appearance, with an outer clear, double-contoured chitinous shell and an inner yellowish membrane with interlaced striations giving the appearance of fibres. In T. limbata of the dog and fox, the egg (Fig. 9) is 72 to 104 microns long by 64 to 80 microns wide. As

deposited by the female worm and as found in the feces, the ascarid eggs (Ascaris, Belascaris, Toxascaris, etc.) show little trace of internal development and some little time is necessary for the formation of the embryo in the shell. Where eggs are found containing developed embryos, it may be taken as evidence that they are not actually from fresh feces but from older material which may contaminate fresh feces collected from an area not properly cleaned before the collection of the fresh sample.

Fig. 11. *Trichuris depressiuscula.* Egg. x 340. From Riley and Fitch, 1921.

The hookworm eggs are elliptical, thin-shelled and usually found with the contents in a state of segmentation. In Ancylostoma caninum of dogs, cats and foxes, the eggs (Fig. 10) are 74 to 84 microns long by 48 to 54 microns wide. In Uncinaria stenocephala of dogs, cats and foxes, the eggs are 63 to 67 microns long by 32 to 38 microns wide.

Whipworm and hairworm eggs are characteristically lemon-shaped,

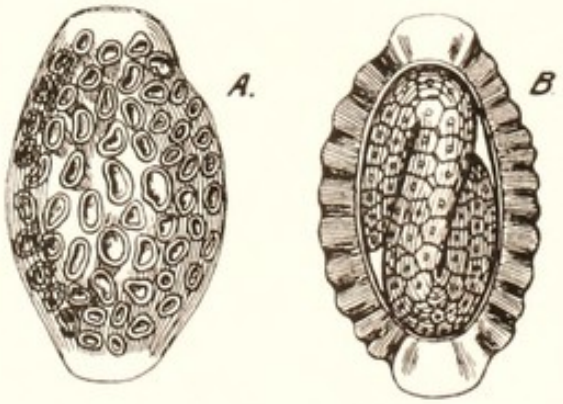

Fig. 12. *Dioctophyme renale.* A, egg showing shell surface with markings. B, egg showing embryo and optical section of shell. x 250. From Railliet, 1893.

with an opercular plug at each end. In Trichuris depressiuscula (T. vulpis) of the dog and fox, the eggs (Fig. 11) are 72 to 80 microns long, according to Railliet, or 77 to 86 microns long, according to measurements of American material, by 37 to 40 microns wide. In T. campanula of the cat, the eggs are 72 microns long by 34 microns

wide. In Capillaria felis-cati of the cat, the eggs are 61 to 64 microns long by 27 to 32 microns wide. This species occurs in the urinary bladder, the eggs passing in the urine. Eggs passing in the urine are quite likely to be found in the feces as a result of contamination. In C. aerophila of the dog, cat and fox, the eggs are 67 to 72 microns

Fig. 13. *Echinopardalis pardalis.* Egg. Enlarged. From Travassos, 1917.

long. This species occurs in the air passages of the lungs and the eggs pass out in the feces. The eggs of this species should be carefully differentiated from those of the whipworm in examining feces from foxes, as this is a common parasite of foxes in North America.

The eggs of the kidney worm of the dog and fox, Dioctophyme

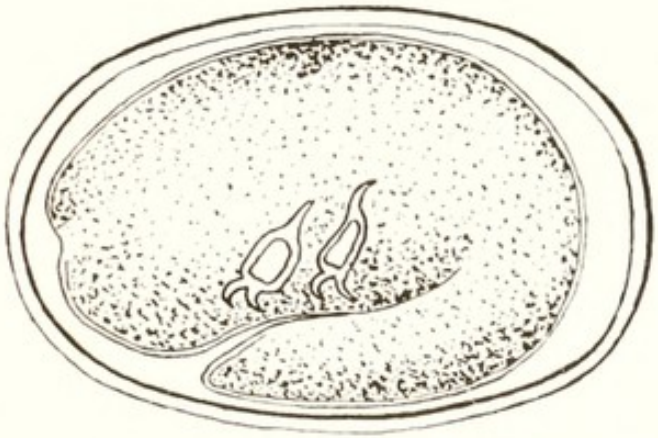

Fig. 14. *Linguatula serrata.* Egg. Enlarged. From Fiebiger, 1912, after Csokor.

renale (Fig. 12), are ellipsoid, brownish, have a thick shell marked with numerous depressions, and are 64 to 66 microns long by 40 to 44 microns wide. When the female worm is in the kidney, the eggs pass in the urine and may be found in feces as a result of contamination.

When the female is in the body cavity, the eggs are passed into the abdominal cavity and are largely picked up by the omentum in its role of protector against foreign objects.

Acanthocephalids, or thorny-headed worms, are rare in dogs and cats, but they sometimes occur, and one species, Oncicola canis, has been found in the United States. The eggs have three shells. The eggs of Echinopardalis pardalis (Fig. 13) of the cat are 53 to 63 microns

Fig. 15. *Synthetocaulus abstrusus.* Larva. x 150. From Railliet, 1893.

long by 38 to 42 microns wide. The egg sizes for O. canis do not appear to have been reported.

The tongue worm, Linguatula serrata, occurs in the nasal cavities of the dog, fox and other animals. The egg (Fig. 14) is elliptical, 90 microns long by 70 microns wide, and contains an embryo when deposited; the embryo has two pairs of bifurcated appendages. The eggs of the tongue worm, which is regarded as a degenerate arachnid,

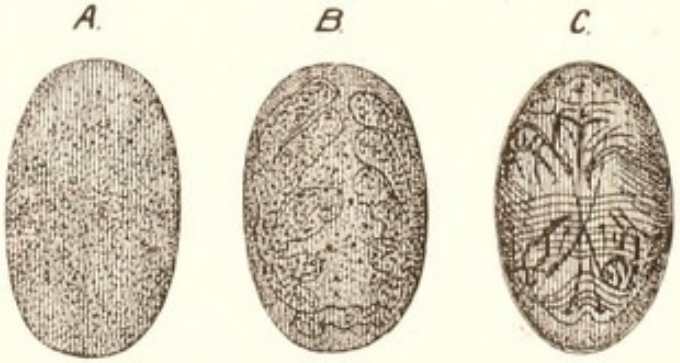

Fig. 16. *Sarcoptes scabiei.* Eggs in various stages of development. x 150. From Railliet, 1893.

are expelled in sneezing, but probably some of them are swallowed and pass in the feces. This parasite has been reported only once from the dog in the United States.

In the case of certain nematodes, such as some of those occurring

in the lungs, the eggs do not pass in the feces, but hatch in the body of the host animal. In such cases larvae are found in the feces. An illustration of this is the cat lungworm, Synthetocaulus abstrusus. The eggs of this worm develop in the alveoli of the lungs and the young worms hatch, make their way up the trachea and are swallowed, appearing in the feces as larvae (Fig. 15).

Numerous objects, such as plant spores, simulate parasite eggs in feces to some extent. Among other things which may be present and which must be eliminated from consideration as worm eggs, are the eggs of mites, both parasitic and free-living. An illustration of the eggs of a sarcoptic mite (Fig. 16) is given here. These eggs are elliptical and rather large, being in the case of Saroptes scabiei canis of the dog about 150 microns long by 80 microns wide. In an early stage the contents of the egg are granular; later the development of the mite in the egg makes an identification easy.

The Eggs and Larvae of Swine Parasites

In view of the fact that one of the protozoan forms is very commonly present in swine feces and may be mistaken for a parasite egg, this form is briefly noted here. It is Balantidium coli, one of the ciliates. In fresh feces it may be found actively moving about, in which case it will resemble the parasite as figured here (Fig. 17). In older feces it is found encysted and is then much more suggestive of a parasite egg.

Tapeworms are rarely found in swine and can not be regarded as normally parasitic in this host. The few records we have of these

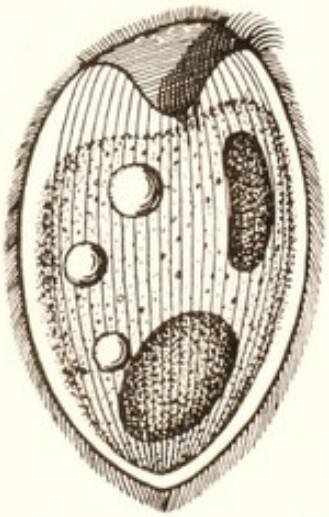

Fig. 17. *Balantidium coli.* Enlarged. From Gedoelst, 1912, after Leuckart.

worms from swine indicate, for the most part, that they are present as a result of the swine having eaten entrails of sheep or other animals, the swine being slaughtered shortly afterwards while the worms were yet present and undigested, or that the worms had developed in the swine but had failed to attain the normal development attained in the usual host, the worms being sterile. In view of this fact, the injunctions occasionally published by some writers, advising the feeding of

pumpkin seed or other vermifuges to swine to remove tapeworms, are not well taken.

Of the flukes present in swine in this country, the common liver fluke, Fasciola hepatica, which occurs in swine, sheep and cattle, may be left for consideration in connection with the parasites of sheep, the

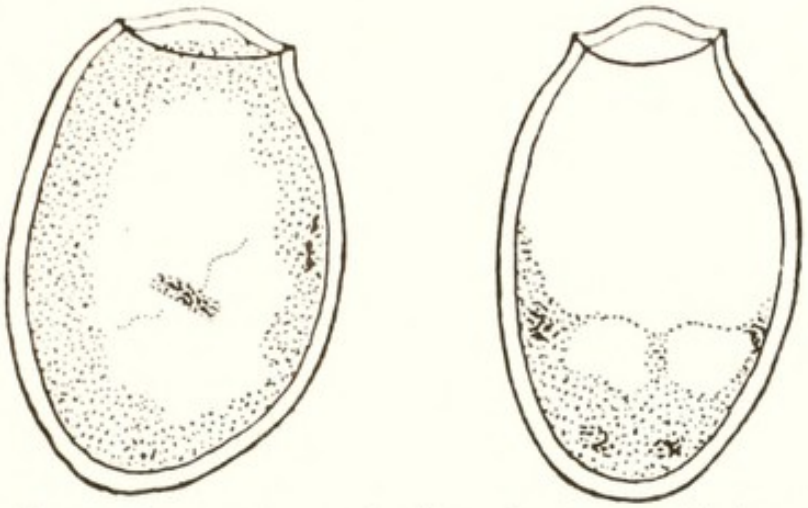

Fig. 18. *Paragonimus westermani.* Eggs from mucus in lungs. x 475. From Ward and Hirsch, 1915.

usual hosts. The lung fluke, Paragonimus westermani, is not uncommon in swine in some parts of the United States, including parts of Texas, Oklahoma and Louisiana. The form in swine has been called P. kellicotti, as a different species from that in man, but the

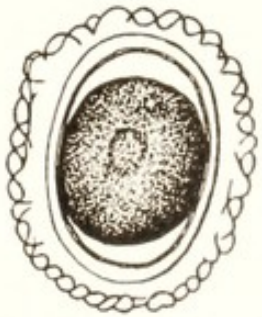

Fig. 19. *Ascaris lumbricoides.* Egg. Enlarged. From Leuckart, 1868.

Japanese writers regard the forms from man and swine as identical. The eggs are coughed up and probably swallowed, as a rule, passing out in the manure. These eggs (Fig. 18) are 78 to 96 microns long by 48 to 60 microns wide, with an operculum or lid at one end.

Of the nematodes of swine, probably the most important, as a rule, is the ascarid, regarded by most authorities at present as identical

with the common ascarid of man, Ascaris lumbricoides, though yet discussed in many texts as A. suilla. The eggs (Fig. 19) of this worm are from 56.5 to 87.5 microns long by 46.5 to 57.5 microns wide; they

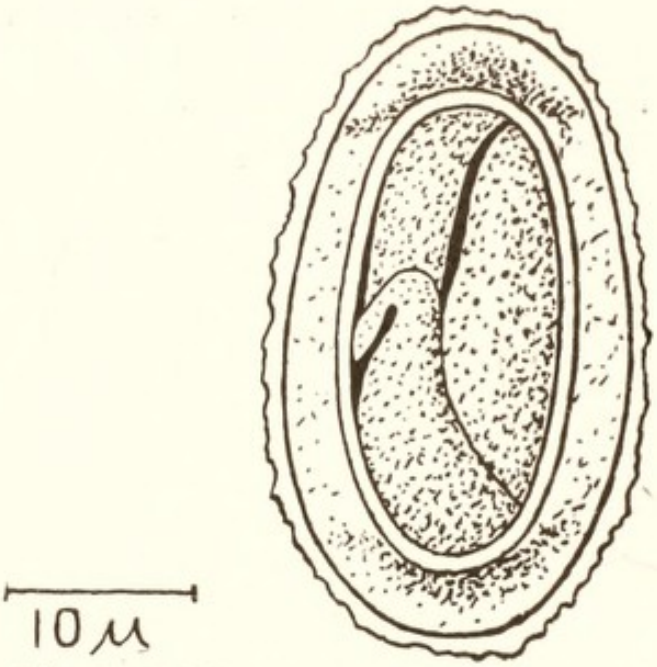

Fig. 20. *Arduenna strongylina.* Egg. From Foster, 1912.

are elliptical, with thick, transparent shells surrounded by a thick layer of albumen which is irregularly mammilated and yellow, and are not segmented when deposited.

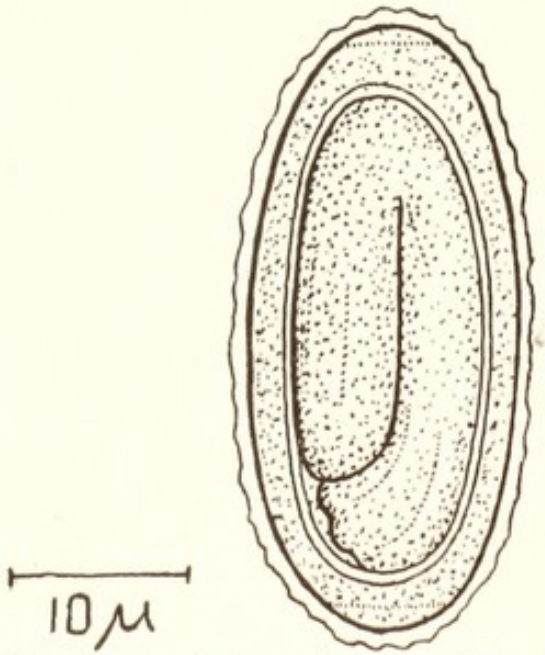

Fig. 21. *Physocephalus sexalatus.* Egg. From Foster, 1912.

There are two species of spirurid worms, Arduenna strongylina and Physocephalus sexalatus, which are not uncommon in the stomach

of swine. The egg of Arduenna strongylina (Fig. 20) is elliptical, 34 to 39 microns long by 20 microns wide, thick-shelled, the shell surrounded by a thin irregular membrane, and contains a well developed embryo when deposited. The egg of Physocephalus sexalatus (Fig. 21) is elliptical, 34 to 39 microns long by 15 to 17 microns wide, thick-shelled, the shell surrounded by a thin irregular membrane, and contains a well developed embryo when deposited.

The eggs of the swine whipworm, Trichuris suis, are 52 to 56 microns long, brown, and lemon-shaped, as in the case of other species of the genus Trichuris, such as Tr. depressiuscula, which was figured (Fig. 11) on page 20. In the case of a closely related and highly important worm, Trichinella spiralis, which occurs in swine, eggs and larvae are not found in the feces, as the eggs, which have a delicate vitelline membrane but no true egg shell, hatch in the maternal uterus and

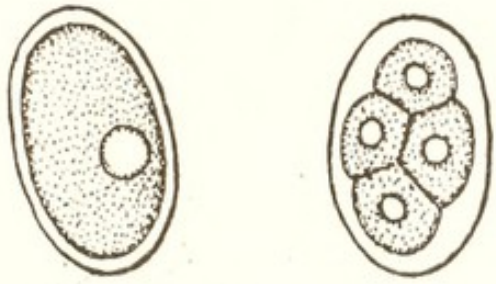

Fig. 22. *Crassiosoma urosubulatum.* Eggs. Enlarged. From Alessandrini, 1909.

the larvae migrate through the tissues of the host, the parasite being transmitted by new hosts eating meat infested with these larvae and not through the medium of the feces.

Swine in this country and elsewhere are infested occasionally by a worm belonging in the group of hookworms. This swine hookworm is known as Globocephalus longemucronatus or Crassiosoma urosubulatum. The description applied to the worm under the first of these names does not appear to conform to the description given for the worm described under the second name, but the points of agreement are such that it is possible that they are identical. The eggs (Fig. 22) of this worm are elliptical and 52 microns long by 35 to 36 microns wide. In this connection it is of interest to note that the Old World hookworm of man, Ancylostoma duodenale, has been reported from swine in the Ellice Islands by O'Connor and that Legg and Reuben state that they find it relatively common in swine in Queensland, Australia. Ransom has recently reported the occurrence of three specimens of the dog

and fox hookworm, Uncinaria stenocephala, from the stomach of a pig in Canada, and notes that there are specimens of Bunostomum

Fig. 23. *Stephanurus dentatus.* Egg, containing embryo. Enlarged. From Taylor, 1900.

trigonocephalum, the sheep hookworm, labeled as collected from the pig, in the collections of the Federal Bureau of Animal Industry. A new species of hookworm from swine in the Island of Trinidad

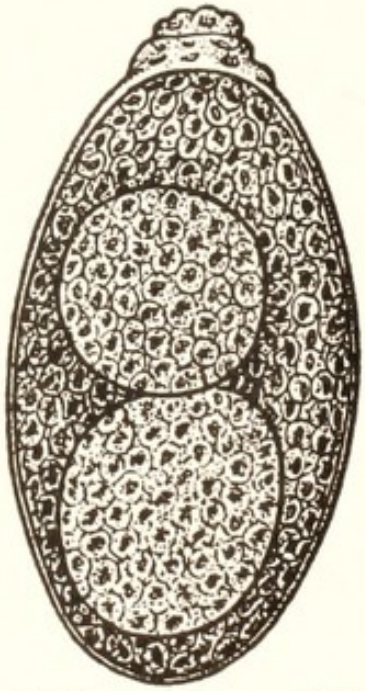

Fig. 24. *Gnathostoma hispidum.* Egg. x 700. From Ciurea, 1911.

has just been described by Ackert and Payne under the name of Necator suillus. The eggs are 56 to 66 microns long by 35 to 40 microns wide.

The eggs of the nodular worm of swine, Œsophagostomum dentatum, are similar in shape to those of the hookworms and are 60 to 80 microns long by 35 to 45 microns wide. Another nodular worm, Bourgelatia diducta, has been described from swine in Annam. The eggs are ellipsoidal, 69 to 77 microns long by 38 to 43 microns wide, and in the morula stage when deposited.

The eggs of the kidney worm of swine, Stephanurus dentatus (Fig. 23), are elliptical, 100 to 120 microns long by 55 to 56 microns wide, thin-shelled, and segmenting when deposited. These eggs pass

Fig. 25. *Strongyloides stercoralis.* Rhabditiform larva from fresh feces. x 310. From Stephens, 1916, after Looss.

out in the urine, but may be found in the feces as a result of mixing urine and feces.

The eggs of the small red stomach worm of swine, Hyostrongylus rubidus (Strongylus rubidus) are elliptical, 45 microns long by 36 microns wide, and segmenting when deposited.

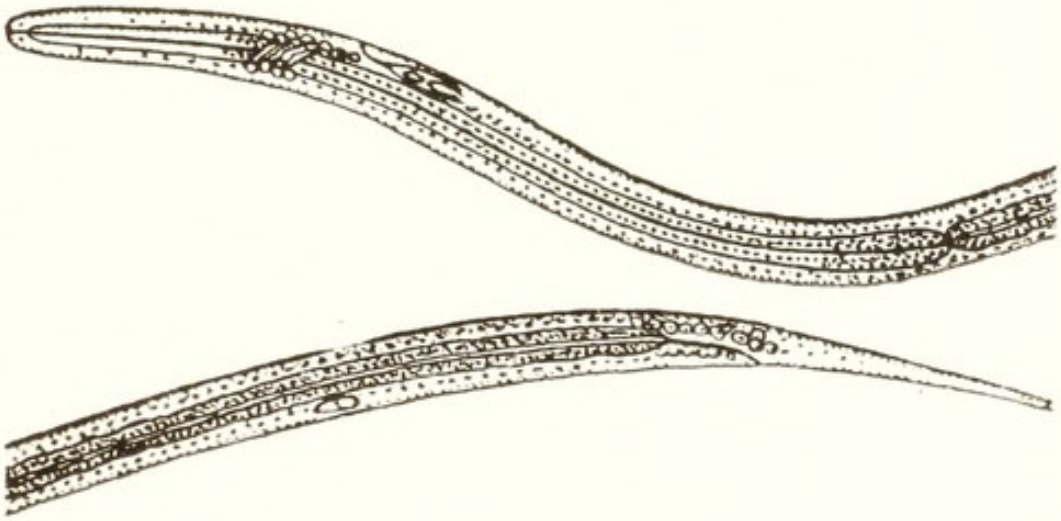

Fig. 26. *Strongyloides stercoralis.* Mature filariform larva. x 620. From Stephens, 1916, after Looss.

An interesting nematode of swine which has not yet been reported from the United States is Gnathostoma hispidum. The eggs (Fig. 24) are 70 to 74 microns long by 39 to 42 microns wide, the shell marked with small depressions and with a wart-like projection or plug at one pole; segmentation begins in the anterior portion of the maternal uterus.

There are two species of lungworms, belonging in the genus Metastrongylus, in swine, these being M. elongatus and M. brevivaginatus. The eggs of these worms hatch in the lungs and the larvae are coughed up and swallowed, as a rule, the larvae passing out in the feces. The larvae of M. elongatus are 220 to 350 microns long by 10 microns wide, clear anteriorly and granular posteriorly, and with a knob-like tail.

The larvae of these lungworms must be distinguished from those of worms of the genus Strongyloides. Members of this genus occur as parasitic females which are parthenogenetic, no males being found. The eggs passing out in the feces usually contain embryos, which soon hatch under ordinary conditions, giving rise to rhabditiform larvae. These rhabditiform larvae may then give rise to filariform larvae,

Fig. 27. *Macracanthorhynchus hirudinaceus.* Egg. Enlarged. From Travassos, 1917.

capable of reinfesting host animals, or may develop to free-living adult males and females, which reproduce and give rise to rhabditiform larvae, which later develop to infective filariform larvae. One species which has been described from swine is Strongyloides suis. Another species which is reported from swine is the one found in ruminants, Str. papillosus. Ackert and Payne have recently reported the form from man, Str. stercoralis, from swine in the Island of Trinidad. The rhabditiform larva (Fig. 25) and the filariform larva (Fig. 26) of the human Strongyloides are figured here.

The eggs (Fig. 27) of the thorny-headed worm of swine, Macracanthorhynchus hirudinaceus (Gigantorhynchus gigas) are oval, 90 to 100 microns long by 51 to 56 microns wide, and provided with 3 shells; the embryo is coiled up and has at the anterior end 4 large hooks and a number of smaller ones.

The Eggs and Larvae of Cattle, Sheep and Goat Parasites

THESE host animals are infested with a number of tapeworms belonging to the group which includes the unarmed tapeworms, or those in which the head or scolex is not provided with hooks. So far as can be judged from the literature, goats are less subject to tapeworm infestation than are sheep and cattle. Tapeworms are often found in the small intestine of ruminants, the usual site for tapeworms

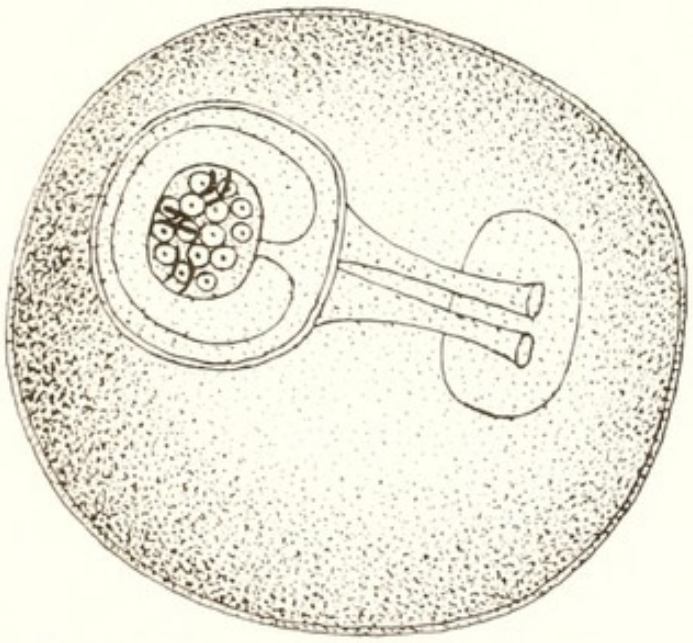

Fig. 28. *Moniezia planissima*. Egg. Enlarged. From Stiles and Hassall, 1893.

in general, but in some cases they are found in the ducts of the liver and pancreas, in the gall bladder and, rarely, in the stomach, as in the case of Thysanosoma actinioides of sheep, this being the fringed tapeworm found in sheep in the western United States. Stilesia hepatica occurs in the biliary ducts of the liver in sheep and goats and in the

stomach of cattle, and Avitellina centripunctata is reported from the stomach of cattle and the small intestine of sheep.

The eggs of tapeworms belonging to the genus Moniezia are thin-shelled and the embryo has, in place of the radially striate embryophore of the taenioid cestodes, a special structure called the piriform apparatus. In its most highly developed condition this consists of a central bulb surrounding the onchosphere, with two so-called horns extending from the bulb and terminating in a disk. The diameter of the eggs of some of the commoner species of Moniezia are as follows:

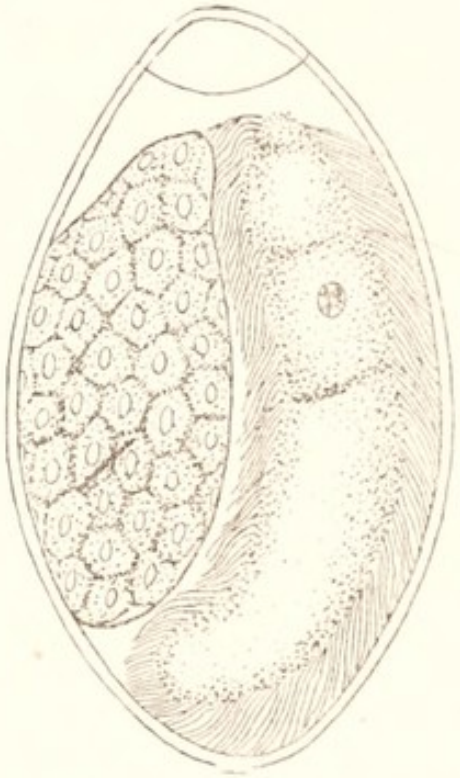

Fig. 29. *Fasciola hepatica.* Egg containing embryo, or miracidium. Enlarged. From Fiebiger, 1912, after Csokor.

M. expansa, 50 to 60 microns; M. planissima (Fig. 28), 63 microns; M. trigonophora, 52 to 60 microns. The eggs of Thysanosoma actinioides are 70 to 105 microns long by 35 to 58 microns wide; the piriform body is without horns in this species. In examining feces of ruminants for evidences of tapeworm infestation, it appears probable that one will usually find gravid segments containing the eggs of the tapeworms present rather than free eggs released from the segments. The gravid segments of Moniezia are wider than long; those of Thysanosoma tend to show a triangular outline when viewed dorso-ven-

trally, the anterior margin of the segment contracting to a blunt point and the posterior margin displaying the fringe-like structure present on the posterior margin of every segment of the worm.

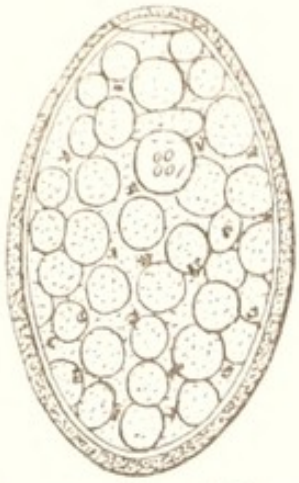

Fig. 30. *Fascioloides magna*. Egg. Enlarged. From Stiles, 1894.

There are few flukes known to occur in ruminants in the United States. The most important one is the common sheep liver fluke,

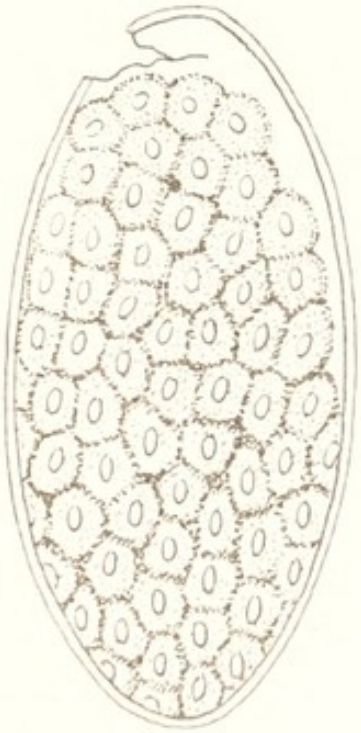

Fig. 31. *Dicrocoelium dendriticum*. Egg. Enlarged. From Fiebiger, 1912, after Csokor.

Fasciola hepatica, which occurs in sheep, goats, cattle and swine. It is rarely present in horses and then usually in young animals. The eggs (Fig. 29) are 130 to 145 microns long by 70 to 90 microns

wide, yellowish-brown, and with an operculum, or lid, at one end. The larger liver fluke of cattle, Fascioloides magna (Fasciola magna), has been reported but rarely from sheep. The eggs (Fig. 30) are 140 to 160 microns long by 90 to 100 microns wide, brown, and operculated.

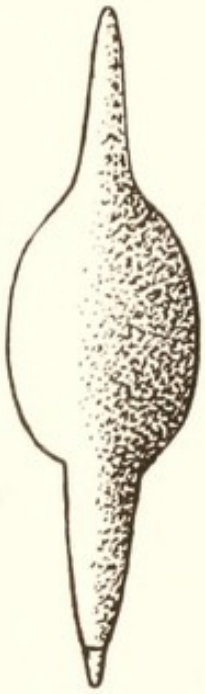

Fig. 32. *Schistosoma bovis.* Egg. Enlarged. From Railliet, 1893, after Sonsino.

The giant liver fluke, Fasciola gigantica, reported from the Philippines, has eggs 125 to 175 microns long by 60 to 100 microns wide. Dicrocoelium dendriticum (Dicrocoelium lanceatum), a fluke common in Europe, but not yet reported from the United States, has eggs (Fig. 31)

Fig. 33. *Gongylonema scutatum.* Egg containing embryo. Enlarged. From Stiles, 1892.

38 to 45 microns long by 22 to 30 microns wide. The conical amphistome, Paramphistomum cervi (Amphistoma conicum), occurs in the rumen and reticulum of cattle and other ruminants and is sometimes found in these animals in the United States. The eggs are

155 to 162 microns long by 82 to 90 microns wide, thickened at one pole and operculated at the other. Schistosomes, a group of flukes inhabiting the blood-vessels, have not yet been reported as present in domesticated animals in the United States. The eggs of these flukes are usually much elongated. In the bovine blood fluke, Schistosoma bovis, the eggs (Fig. 32) are 160 to 180 microns long by 40 to 50 microns wide, with a pronounced swelling in the middle and armed

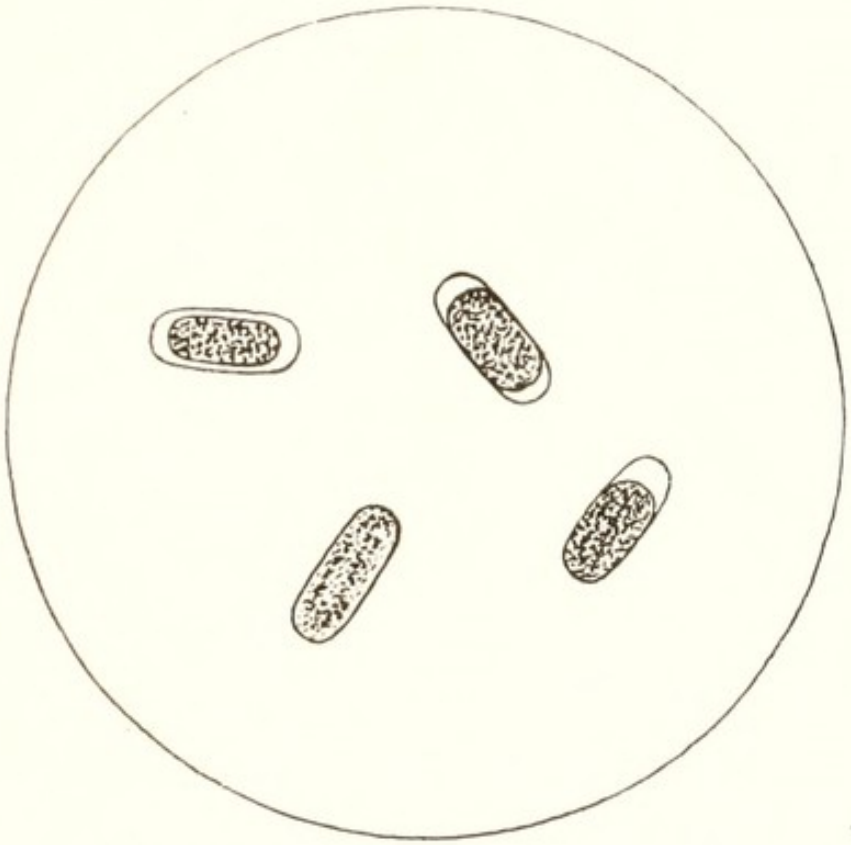

Fig. 34. *Gaigeria pachyscelis*. Eggs. Enlarged. From Gaiger, 1911.

with a pointed spine at each end. In the case of this species, the eggs may pass in the manure and in the urine, as the veins both of the rectum and of the bladder may be inhabited by the flukes.

Ruminants are infested by a large number of species of nematodes, some of which occur in the digestive tract or respiratory tract with the evidence of their presence in the form of eggs and larvae in the feces, and some of which occur in the blood, body cavity and various tissues and which cannot be determined as present by fecal examinations.

Two of the swine parasites of which the eggs were figured in the previous article in this series, namely, Arduenna strongylina and Physocephalus sexalatus, have recently been reported as accidental parasites of cattle in the United States by Dikmans, and another swine parasite, the kidney worm, Stephanurus dentatus, has been reported from cattle by Hall. The gullet worm of cattle, sheep and goats, occasionally present in horses, Gongylonema scutatum, has an egg (Fig. 33) 56 to 60 microns long by 32 to 36 microns wide, containing at the time of oviposition an embryo provided with a hook-like process on one side near the anterior end, the opposite side of the anterior end of the worm showing an annulate marking. The eggs

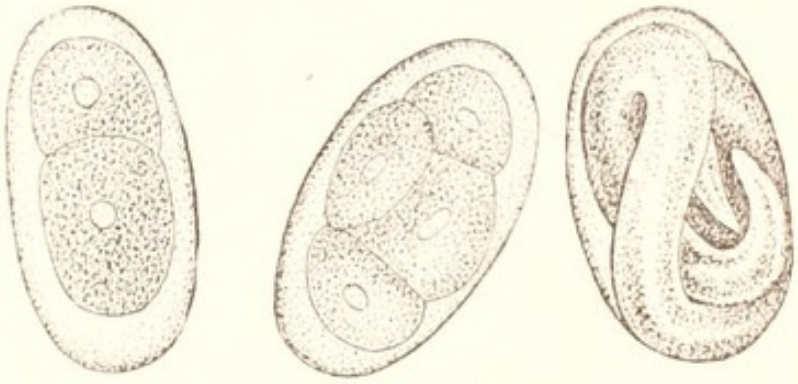

Fig. 35. *Haemonchus contortus*. Eggs in various stages of development. x 380. From Veglia, 1916.

of another gullet worm, G. verrucosum of sheep and goats, are 45 to 50 microns long by 25 to 27 microns wide. The eggs of the cattle ascarid, Ascaris vitulorum, are 75 to 80 microns in diameter. The ascarids found in sheep appear to be specimens of Ascaris lumbricoides of man and swine, present as accidental parasites in an unusual host and quite generally incompletely developed and devoid of eggs, or at least of fertile eggs.

The eggs of the numerous strongyles occurring in the digestive tract of ruminants are commonly more or less elliptical and thin-shelled. Although the egg sizes overlap in many cases to such an extent that it is often impossible to determine the species present, a reasonable probability as to the presence of certain worms may be

established in the case of some worms. Haemonchus contortus is so commonly present that the presence of eggs falling within the size range for this species may be taken as a fairly safe indication that this worm is present.

The egg sizes in microns for some of the larger strongyles, those having a well developed mouth capsule and belonging to the family Strongylidae, are as follows: The cattle hookworm, Bustomum phlebotomum, 75 to 98 long by 40 to 50 wide; the sheep hookworm, Bunostomum trigonocephalum, 75 to 83 long by 38 to 45 wide; the cattle nodular worm, Proteracrum radiatum, 75 to 85 long by 40 to 50 wide; the common sheep nodular worm, Proteracrum columbianum, 65

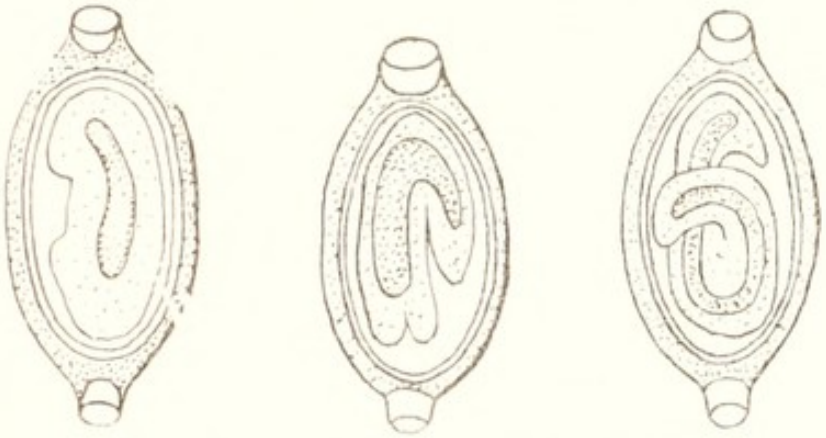

Fig. 36. *Trichuris ovis.* Eggs. Enlarged. From Fiebiger, 1912, after Csokor.

to 75 long by 40 to 45 wide; the goat hookworm, Proteracrum asperum, reported from the Canal Zone, 83 to 85 long by 55 to 60 wide; the veined nodular worm of sheep, Hysteracrum venulosum, 85 to 90 long by 45 to 55 wide; the sheep and goat nodular worm, Gaigeria pachyscelis (Fig. 34), reported from India and the Belgian Congo, 105 to 118 long by 50 to 55 wide; the strongyle from the large intestine of ruminants, Chabertia ovina, 90 to 100 long by 50 wide.

The egg sizes in microns for some of the trichostrongyles, which are the smaller strongyles, those without a well developed mouth capsule and belonging in the family Trichostrongylidae, are as follows:

The common stomach worm, Haemonchus contortus (Fig. 35), 75 to 95 long by 40 to 50 wide; H. similis, reported from the United States by Dikmans, 70 to 78 long by 35 to 42 wide; Ostertagia ostertagi, 65 to 80 long by 30 to 40 wide; O. circumcincta, 75 to 100 long by 35 to 50 wide; O. trifurcata, 85 to 95 long by 40 to 48 wide; O. marshalli, 160 to 200 long by 75 to 100 wide; O. bullosa, 85 long by 65 wide; Cooperia punctata, 65 to 72 long by 30 wide; C. oncophora, 60 to 80 long by 30 wide; C. pectinata, 70 to 80 long by 36 wide; C. curticei, 63 to 70 long by 30 to 32 wide; Nematodirus filicollis, 130 to 200 long by 70 to 95 wide; N. spathiger, 150 to 220 long by 80 to 110 wide; N. abnormalis, 160 to 230 long by 85 to 115 wide; Trichostrongylus extenuatus, 70 to 80 long by 35 to 45 wide; T. colubriformis, 73 to 80 long by 40 to 43

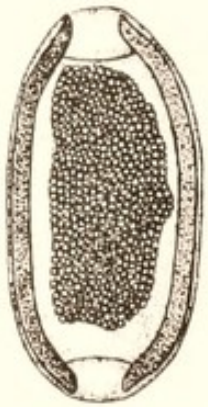

Fig. 37. *Capillaria brevipes*. Egg. Enlarged. From Ransom, 1911.

wide; T. probolurus, 76 to 80 long by 43 to 46 wide; T. vitrinus, 84 to 90 long by 46 to 50 wide; T. capricola, 75 to 95 long by 35 to 45 wide.

The Y-worm of cattle and carabao, Syngamus laryngeus, a relative of the gapeworm of poultry, has been reported from the Philippines by Hall and has recently been reported by Ransom and by Bagué from Porto Rico. The eggs of this worm are 80 microns long by 40 microns wide.

The eggs of the common whipworm of ruminants, Trichuris ovis (Fig. 36), are lemon-shaped and 70 to 80 microns long by 30 to 35 microns wide. Those of the hair-worms, belonging to the genus Capillaria, are also lemon-shaped, the dimensions for the various

species being as follows: Capillaria bovis of cattle, 47 microns long by 27 microns wide; C. brevipes (Fig. 37) of sheep, 50 microns long by 25 microns wide; C. longipes (Fig. 38) of sheep, 45 to 50 microns long by 22 to 25 microns wide.

Fig. 38. *Capillaria longipes.* Egg. Enlarged. From Ransom, 1911.

As noted in the paper on eggs and larvae of swine parasites, the eggs of species of the genus Strongyloides contain well developed embryos when passed, and these eggs hatch promptly. The eggs may be found in fresh feces, but in older feces the free larvae are present.

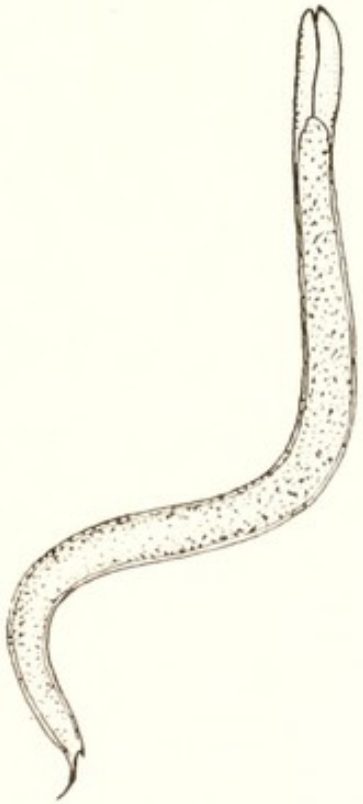

Fig. 39. *Synthetocaulus capillaris.* Larva. Enlarged. From Fiebiger, 1912.

Brumpt, in 1921, reported a new Strongyloides, S. vituli, from cattle, but no description of this species is yet available. The eggs of S.

papillosus of sheep and goats are 40 to 60 microns long by 20 to 25 microns wide. The rhabditiform larvae and the filariform larvae are similar in a general way to those of S. stercoralis, figured in the paper on eggs and larvae of swine parasites.

As previously noted, the eggs of the lung-worms belonging to the family Metastrongylidae hatch in the lungs and the larvae ascend the trachea and are usually swallowed, passing out in the manure. The larvae of the common lungworm of cattle, Dictyocaulus viviparus, are 280 microns long by 25 microns wide when first hatched; these larvae have a button-like head and a rather blunt tail. The larvae of the common sheep lungworm, D. filaria, are somewhat similar. The larvae of the hair lung-worm of sheep, Synthetocaulus rufescens, are 300 to 400 microns long by 16 to 18 microns wide and have a tail prolonged by an undulate appendix. The larvae of S. capillaris (Fig. 39) are similar and are 230 to 300 microns long by 20 microns wide.

The Eggs and Larvae of Horse Parasites

IN general the parasites infesting horses infest asses and mules also. Horses are infested with three species of tapeworms, all of them having heads which are not provided with hooks and all of them

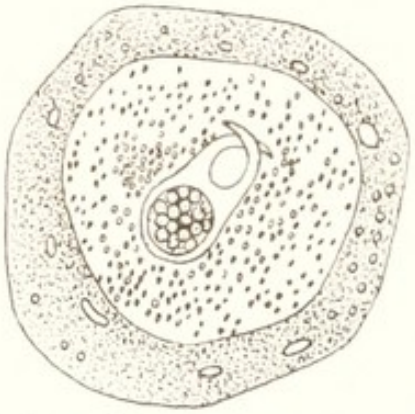

Fig. 40. *Anoplocephala perfoliata.* Egg. x 360. From Yorke and Southwell, 1921.

occurring in the United States. The eggs of the tapeworms are provided with a piriform apparatus such as was described in the previous paper on eggs and larvae of ruminant parasites. The egg of

Fig. 41. *Schistosoma indicum.* Egg. Enlarged. From Skrjabin, 1913.

Anoplocephala magna is described as oval, round or polyhedral, and is about 88 microns long by 50 to 60 microns wide. The egg of A. perfoliata (Fig. 40) is approximately spherical and is 65 to 80 microns

in diameter. The egg of A. mamillana is 50 to 60 microns in diameter according to some writers; Fiebiger states that it is oblong.

Of the flukes infesting the horse, Fasciola hepatica, Fascioloides magna and Dicrocoelium dendriticum have already been considered in previous papers. In India the horse is infested with a blood fluke, Schistosoma indicum, the eggs passing in the manure and in the urine. The egg (Fig. 41) is oval, with a spine at one end. In the fluke these eggs are from 92 to 100 microns, rarely 112 microns, long by 42 to 44 microns, rarely 52 microns, wide, with a spine 13 to 14 microns long; eggs from the rectum of horses are 120 to 140 microns, rarely 152 microns, long by 68 to 72 microns wide. The remaining flukes reported from horses are mostly amphistomes, flukes having an oral

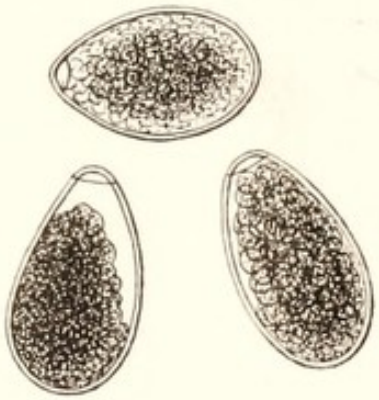

Fig. 42. *Gastrodiscus aegyptiacus*. Eggs. x 100. From Railliet, 1893.

sucker at the anterior end and having the ventral sucker or acetabulum at the posterior end. Of these, Gastrodiscus aegyptiacus has ovoid eggs (Fig. 42) 150 to 170 microns long by 90 to 95 microns wide, according to some writers, or 170 to 190 microns long by 110 microns wide, according to Looss. The eggs of G. secundus are 150 to 160 microns long by 90 to 100 microns wide. The eggs of Pseudodiscus collinsi and Ps. stanleyi do not appear to have been observed as yet.

There are numerous nematodes infesting the horse. Among these is a species of Strongyloides, S. westeri, which is so far reported only from Holland. The life history of this worm is similar to those of species of Strongyloides referred to in previous papers; the eggs hatch

soon after their passage from the host and if manure is not examined promptly after it is passed, larvae will be found instead of eggs. The eggs of S. westeri are thin-shelled, 40 to 52 microns long by 32 to 40 microns wide, deposited in strings, similar to those described by Ransom for S. ovocinctus from the prong-horned antelope. The rhabditiform larva is 495 to 525 microns long by 15 to 20 microns wide.

Among the most important of the spirurid worms of the horse are the stomach worms belonging to the genus Habronema. The eggs of H. muscae (Fig. 43) are thin-shelled and are 40 to 50 microns long by

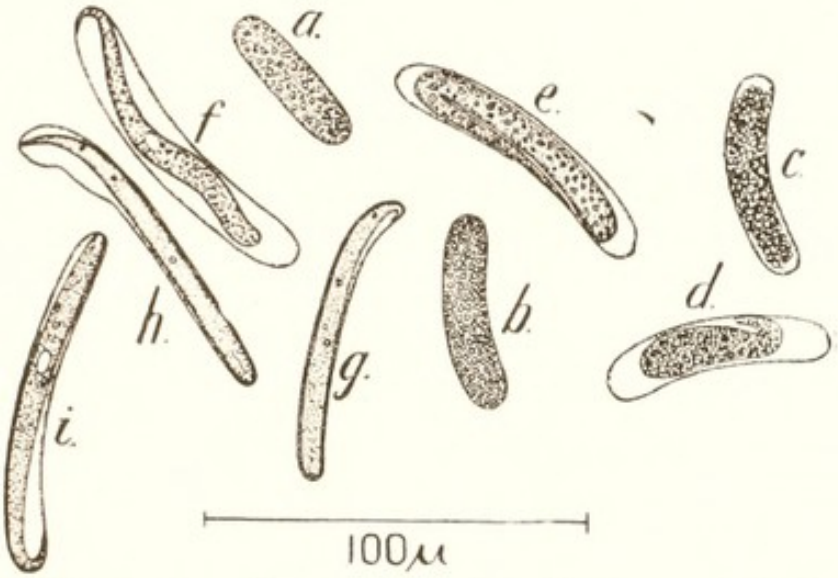

Fig. 43. *Habronema muscae*. Eggs. *a, b, c, d,* early stages of development; *e,* containing embryo doubled on itself; *f,* with embryo almost straightened out; *g, h, i,* with flexible egg shell applied to embryo in a manner resembling that of a cuticle. From Ransom, 1913.

10 to 12 microns wide in an early stage of development in the uterus. As the embryo develops the egg becomes longer and at a stage where the embryo is doubled on itself is 87 microns long and about the same width as given above. Later the shell becomes closely applied to the embryo except in the tail region and in this stage the shell is very suggestive of a cuticle. The embryos are 85 to 100 microns long by 5 to 7 microns wide, with a rounded anterior end. The eggs of H. microstoma are oblong and truncate, and are 45 to 49 microns long by 16 microns wide. The embryo is 90 to 98 microns long. The eggs of H. megastoma are elongate, 40 to 57 microns long by 10 to 18

microns wide, according to Hill. Railliet states in his Traité that these eggs are 330 to 350 microns long by 8 microns wide, and these measurements have been copied by subsequent authors, but apparently the figures for length here have been multiplied as the result of a shifted decimal point due to a printer's error or a lapsus of some sort. Hill states that the embryo is about 104 microns long, whereas Railliet states that it is 600 to 700 microns long, perhaps as the result of a lapsus similar to that in the case of the egg measurements. Gongylonema scutatum, the gullet worm of sheep and cattle, occurs in horses also, and has been collected by the writer from the horse at Bethesda, Maryland. Physocephalus sexalatus, one of the stomach worms of swine, has been reported from the ass by Seurat, but the

Fig. 44. *Strongylus vulgaris*. Egg. Enlarged. From Winchester, 1892.

description of his specimens does not agree in all respects with the description of P. sexalatus and it seems advisable to reserve judgment in regard to the occurrence of this worm in the horse for the present.

Dioctaphyme renale (Fig. 12), the giant kidney worm of the dog, has been reported at least four times from the horse by various writers.

In spite of the fact that the numerous strongyles in the large intestine of the horse constitute the most important group of worm parasites of the horse, there is an astonishing scarcity of figures of the eggs and of egg measurements. It is of great interest to note that the only figure of one of these strongyle eggs which has been found by the present writer is one published by the late Dr. J. F. Winchester thirty years ago. This egg (Fig. 44), like the remainder of Winchester's figures, is labeled Strongylus armatus, but the other figures are evidently figures of S. vulgaris, and the sizes he gives for the egg, 92 microns long by 54 microns wide, appear to be correct for S. vulgaris

Winchester's paper is an excellent piece of work, giving excellent illustrations of S. vulgaris eight years before Looss in Egypt definitely separated out and named this species. It shows what good work the practicing veterinarian can do along investigational lines when he has the time, the inclination and the taste for painstaking work.

Fig. 45. *Dictyocaulus arnfieldi*. Larvae, the one at the left in the process of leaving the egg shell. x 150. From Railliet, 1893.

The eggs of the other strongyles of the large intestine of the horse are probably similar in a general way to those of S. vulgaris in appearance. The egg dimensions which have been published are as follows: Cylicostomum euproctum, 80 to 100 microns long by 50 to 60 microns wide; C. insigne, 75 to 86 microns long by 45 to 50 microns wide; C. goldi, 100 microns long by 50 microns wide; Œsophagodontus robustus, 100 to 130 microns long by 50 to 60 microns wide; Triodontophorus minor, 87 microns long, according to some writers, or 80 to 90 microns long by 40 to 50 microns wide, according to Boulenger; Tr. serratus, 130 microns long; Tr. intermedius, 90 to 100 microns long by 40 to 50 microns wide; Tr. tenuicollis, stated as similar to those of Tr. intermedius; Tr. brevicollis, 90 to 100 microns long; Acheilostoma paranecator, 63 to 64 microns long by 43 microns wide. The egg

of the small trichostrongyle, Trichostrongylus axei, from the stomach of the horse, is 100 to 112 microns long by 63 microns wide, according to most writers; Wolffhuegel says the eggs from Argentine specimens

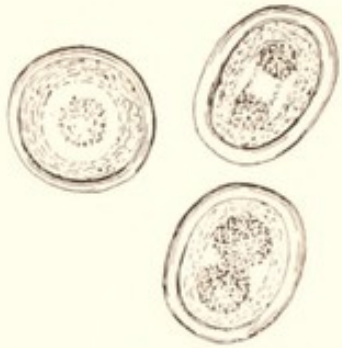

Fig. 46. *Ascaris equorum*. Eggs. x 130. From Railliet, 1893.

are 80 microns long by 25 microns wide, a discrepancy that calls for further investigation.

The egg of the horse lungworm, Dictyocaulus arnfieldi (Fig. 45) is 80 to 100 microns long by 50 to 60 microns wide and contains an embryo when deposited. These eggs hatch in the lungs and the larvae ascend the trachea, passing out in the manure. The larvae (Fig. 45)

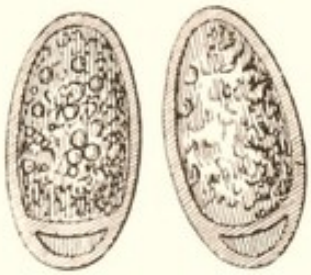

Fig. 47. *Oxyuris equi*. Eggs. x 200. From Railliet, 1893.

are 400 to 490 microns long by 14 to 18 microns wide, with a thin transparent caudal appendix.

The eggs of the horse ascarid, Ascaris equorum (Fig. 46) are almost globular, 90 to 100 microns in diameter, and are not segmenting when deposited. The egg of the pinworm, Oxyuris equi (Fig. 47), is 85 to 95 microns long by 40 to 45 microns wide, asymmetrical, somewhat flattened on one side, and provided with a clearly defined structure resembling an operculum or lid at one end. The eggs of the viviparous pinworm of the horse, Probstmayria vivipara, a species occurring in the United States, Europe and elsewhere, are elongate oval, 58 to 100 microns long by 40 to 75 microns wide.

The Eggs and Larvae of Poultry Parasites

THE eggs of most of the flukes occurring in poultry are of the usual elliptical shape and provided with an operculum at one end. Some of the egg sizes in microns are as follows: Typhlocoelum obovale (duck; trachea, bronchi, lungs, etc.), 154 to 180 by 90; Tracheophilus sisowi (duck; air passages of lungs), 122 by 63; Opisthorchis simulans (duck; biliary canals), 28 by 16 to 18; Metorchis xanthosomus (duck; biliary canals), 27 to 32 by 14; Echinostoma revolutum (duck,

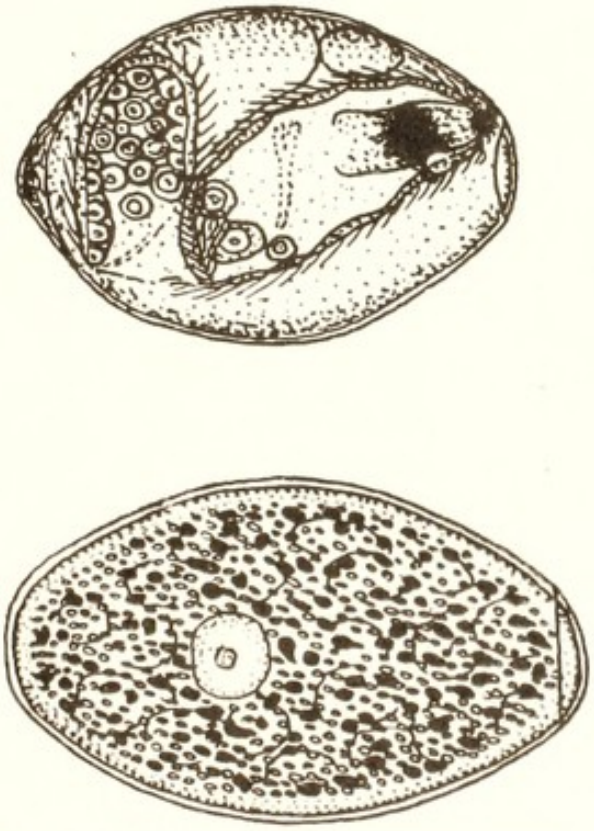

Fig. 48. *Echinostoma revolutum.* Eggs in various stages of development. x 34. From Johnson, 1920.

goose, swan, chicken; intestine; U. S.), 94 to 114 (Fig. 48); E. recurvatum (duck, chicken; intestine), 110 by 80; Hypoderaeum conoideum (duck, goose, chicken; intestine), 95 to 108 by 61 to 68; Prosthogonimus

cuneatus (chicken, peafowl; bursa of Fabricius; U. S.), 22 to 27 by 13 to 16; P. ovatus (chicken; bursa of Fabricius and oviduct), 22 to 24 by 13; P. intercalandus (chicken; oviduct and body cavity), 29 by 15; P. pellucidus (chicken; bursa of Fabricius and oviduct), 27 to 29 by 11 to 13; P. japonicus (chicken; probably bursa of Fabricius), 24 by 12; Strigea gracilis (duck; intestine), 110 by 67; Cyathocotyle orientalis (duck; ceca and small intestine), 100 by 65.

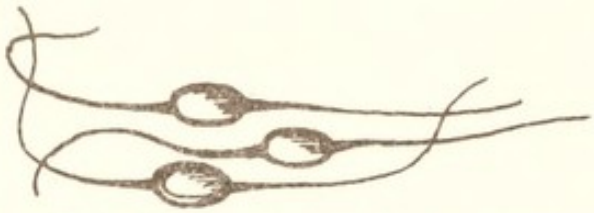

Fig. 49. *Catatropis verrucosa.* Eggs. x 215. From Neumann, 1909, after Dujardin.

Some fluke eggs are not of the conventional shape given above. The eggs of Catatropis verrucosa (Fig. 49) are elliptical, 23 microns long by 11 microns wide, with a filament 160 microns long at each pole; this fluke occurs in the cecum and rectum of the goose. The

Fig. 50. *Choanotaenia infundibulum.* Eggs. x 425. From Guberlet, 1916.

eggs of Bilharziella polonica are elongate anteriorly and have a small terminal spine posteriorly; this fluke occurs in the blood vessels of the duck.

There are many species of tapeworms which occur in the intestines of poultry. A very small number of these belong to the group of

bothriocephalid worms and as such have thick-shelled eggs with an operculum or lid at one end. Such an egg has already been figured in a previous paper for a related worm, Diphyllobothrium latum, one of the dog tapeworms. Schistocephalus solidus, a tapeworm from the intestine of the duck, has similar eggs, the eggs being 44 to 54 microns long by 35 to 38 microns wide.

Fig. 51. *Hymenolepis anatina*. Egg. Enlarged. From Braun, 1897, after Schmidt.

The eggs of tapeworms belonging to the family Hymenolepididae have several thin, transparent shells or membranes, as a rule. In the case of Choanotaenia infundibulum (chicken, turkey; U. S.), the eggs (Fig. 50) are oval, with a thin membrane next to the onchosphere, then a thick, smooth membrane, and then one or two very thick outer membranes, 60 to 65 microns long by 40 to 45 microns wide, and with a delicate appendage at each pole. The eggs of Hymenolepis anatina

Fig. 52. *Hymenolepis tenuirostris*. Egg. x 240. From Krabbe, 1869.

(duck, swan) have the characteristic shape figured here (Fig. 51) and are 125 to 175 microns long by 90 microns wide. The eggs of H. tenuirostris (duck, goose) are almost cylindrical and 85 microns long (Fig. 52). Usually these tapeworm eggs are globular or subglobular to elliptical. The diameters of the eggs are given here in microns for the following species: H. carioca (chicken, turkey; U. S.), 36 to 75; H. exilis (chicken), 56 to 65; H. cantaniana (chicken, turkey, peafowl; U. S.),

45 to 60; H. columbae (pigeon), 36; H. collaris (duck, goose), 42 to 44; H. megalops (duck; U. S.), 45 to 57; H. venusta (duck), 47 by 30; H. sagitta (duck), 44 by 34; H. setigera (goose), 53 by 28; H. fedtschenkowi (chicken), 75 by 50; Drepanidotaenia lanceolata (goose,

Fig. 53. *Drepanidotaenia lanceolata.* Egg. x 300. From Stiles, 1896, after Railliet.

duck), 50 by 35 (Fig. 53); Monopylidium gallinarum (chicken), 35; Amoebotaenia sphenoides (chicken; U. S.), 42 (Fig. 54); Metroliasthes lucida (turkey, chicken, guinea fowl; U. S.), 75 by 50 (Fig. 55).

Fig. 54. *Amoebotaenia sphenoides.* Egg. x 374. From Meggitt, 1914.

The eggs of tapeworms belonging to the family Davaineidae also have thin, transparent shells or membranes and are very similar to those of tapeworms belonging to the Hymenolepididae. Those of poultry tapeworms are usually globular or subglobular, but sometimes

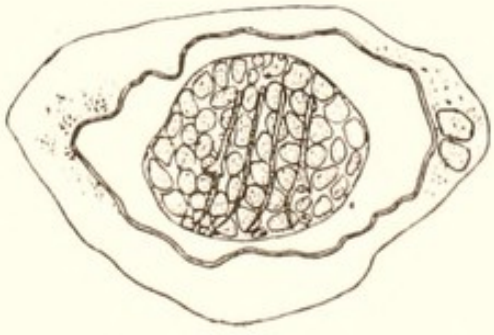

Fig. 55. *Metroliasthes lucida.* Egg. x 758. From Ransom, 1900.

elliptical. The diameters of the eggs are given here in microns for the following species: Davainea proglottina (chicken; U. S.), 35 to 40 (Fig. 56); D. tetragona, chicken, turkey, guinea fowl; U. S.), 25 to 50

(Fig. 57); D. friedbergeri (turkey), 34 to 38; D. bothrioplitis (chicken), 25 to 40; D. echinobothrida (chicken; U. S.), 25 to 50; D. cesticillus (chicken, turkey, guinea fowl; U. S.), 36 to 42 (Fig. 58), according to some writers, or 65 by 50, according to others; D. microcotyle (duck), 40; D. vigintivasus (chicken), 55.

The family Anoplocephalidae is represented by the species Bertiella delafondi parasitic in the intestine of the pigeon. The egg (Fig. 59) of this worm has 2 thin shells outside of the onchosphere and is 55 to

Fig. 56. *Davainea proglottina.* Egg. Enlarged. From Stiles, 1896, after Blanchard.

65 microns in diameter; the piriform apparatus, noted in a previous paper as present in eggs of cattle tapeworms belong to this same family, Anoplocephalidae, is not present.

The family Fimbriariidae is represented by the species Fimbriaria fasciolaris, parasitic in the duck and goose. The egg has thin shells

Fig. 57. *Davainea tetragona.* Egg. Enlarged. From Lopez Neyra, 1920.

and is 37 to 45 microns long by 21 to 23 microns wide.

The eggs of nematodes belonging to the superfamily Spiruroidea are usually elliptical and contain embryos when deposited. Most of the following species occur in the digestive tract, usually embedded more or less in the tissues. Oxyspirura mansoni and O. parvovum

occur in the eyes, but the eggs pass through the lachrymal ducts and are swallowed, escaping in the droppings. Filaria gallinarum is a spirurid, not a Filaria, but its description does not permit of its assignment to a genus of spirurids at present. The dimensions of some of these spirurid eggs in microns are as follows: Filaria gallinarum (chicken), 40 by 24; Oxyspirura mansoni (chicken, turkey, peafowl; U. S.), 50 to 65 by 40 to 45 (Fig. 60); O. parvovum (chicken), 33 to 45

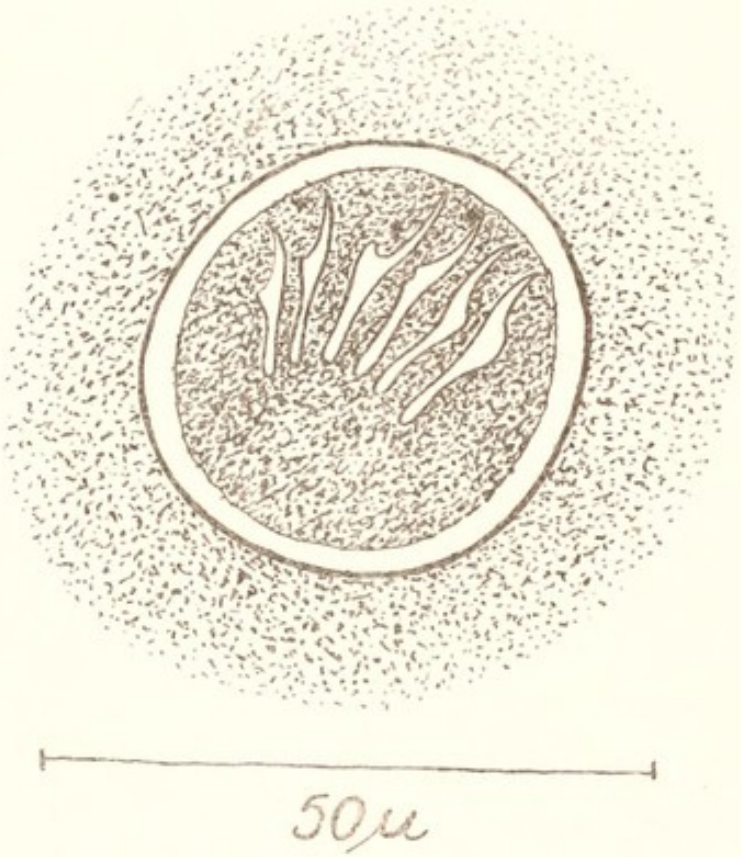

Fig. 58. *Davainea cesticillus*. Egg in capsule. From Lopez Neyra, 1920.

by 25 to 30; Streptocara pectinifera (chicken, guinea fowl), 33 by 20; Gongylonema ingluvicola (chicken; U. S.), 50 by 36; Dispharynx spiralis (chicken, guinea fowl, pigeon), 36 to 40 by 19 to 21; Cheilospirura hamulosa (chicken; U. S.), 30 by 20; Tetrameres fissispina (duck, turkey, chicken, pigeon), 50 by 28; T. confusa (chicken, turkey, pigeon), 33 by 24; T. gigas (duck) 50 by 21; Physaloptera bulbosa (peafowl), 44 by 26.

The eggs of nematodes belonging to the superfamily Strongyloidea are usually thin-shelled and elliptical and are usually segmenting when deposited. The dimensions in microns of some of the eggs of worms

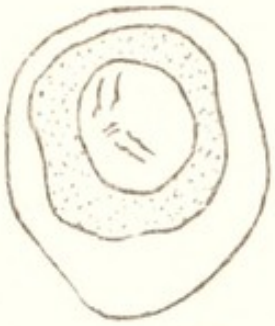

Fig. 59. *Berticlla delafondi.* Egg. Enlarged. From Johnston, 1918.

in this superfamily are as follows: Trichostrongylus tenuis (chicken, duck, goose; cecum), 66 to 75 by 35 to 42; Ornithostrongylus quadriradiatus (pigeon; intestine; U. S.), 70 to 75 by 38 to 40;

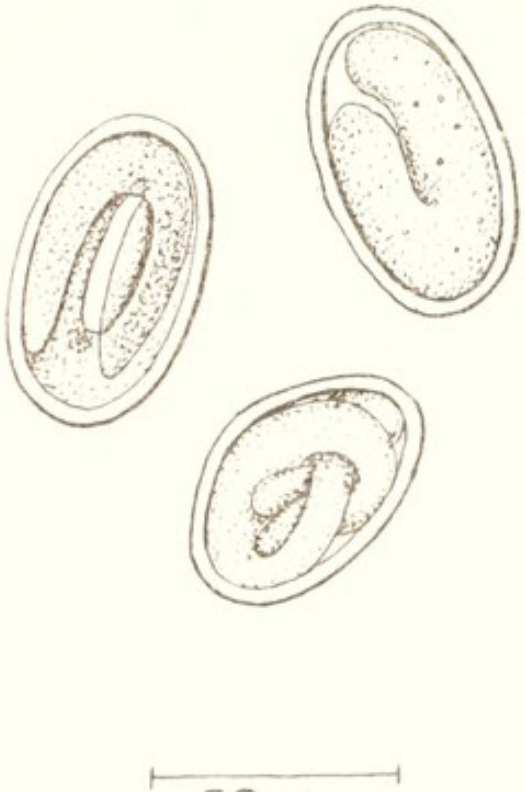

Fig. 60. *Oxyspirura mansoni.* Eggs. From Ransom, 1904.

Epomidiostomum orispinum (goose; esophagus and proventriculus), 95 by 55; E. anatinum (duck; gizzard), 74 to 80 by 48 to 50; Syngamus trachealis (chicken, turkey, peafowl; U. S.), 85 to 90 by 50, with

operculum at each end (Fig. 61); S. bronchialis (goose, duck; larynx, trachea and bronchi), 80 to 90 by 60, with an operculum at one end. The eggs of Amidostomum anseris (goose, duck; esophagus, proventriculus and gizzard) are 84 microns long by 50 microns wide and contain an embryo when deposited.

The eggs of the worms belonging to the family Heterakidae of the superfamily Oxyuroidea are usually thick-shelled and are usually not yet segmenting when deposited. The dimensions of some of these eggs in microns are as follows: Heterakis papillosa (chicken, turkey, guinea fowl, peafowl, duck, goose; ceca; U. S.), 63 to 71 by 38 to 48

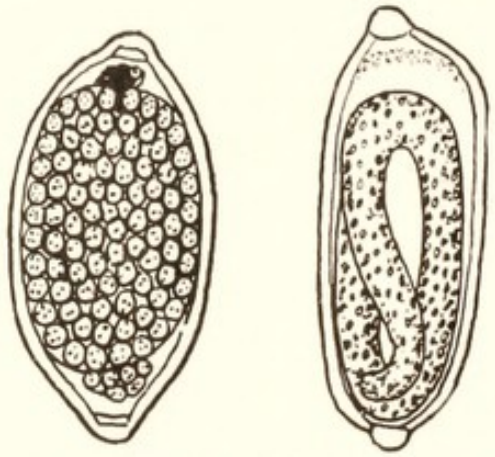

Fig. 61. *Syngamus trachealis*. Eggs in various stages of development. Enlarged. From Neumann, 1909, after Railliet.

(Fig. 62); Ascaridia perspicillum (chicken, turkey, guinea fowl; intestine; U. S.), 75 to 80 by 45 to 50; A. lineata (duck, chicken; intestine), 80 by 50; A. columbae (pigeon; intestine; U. S.), 60, 68, 72 and 80 to 90 microns long, according to various writers, by 40 to 50 microns wide. A member of the same family, Subulura differens (chicken, guinea fowl; intestine), has eggs which are almost spherical, 59 microns long by 50 microns wide, containing embryos when deposited.

The worms belonging to the superfamily Trichuroidea have lemon-shaped eggs as a rule. The dimensions in microns of the eggs of some of these worms are as follows: Capillaria retusa (chicken,

guinea fowl; intestine and ceca), 45 to 65 by 18 to 24, or by 28 to 32, according to some writers; C. collare (chicken; intestine), 66 by 30; C. meleagris (turkey; intestine and ceca), 54 to 56 by 25 to 27;

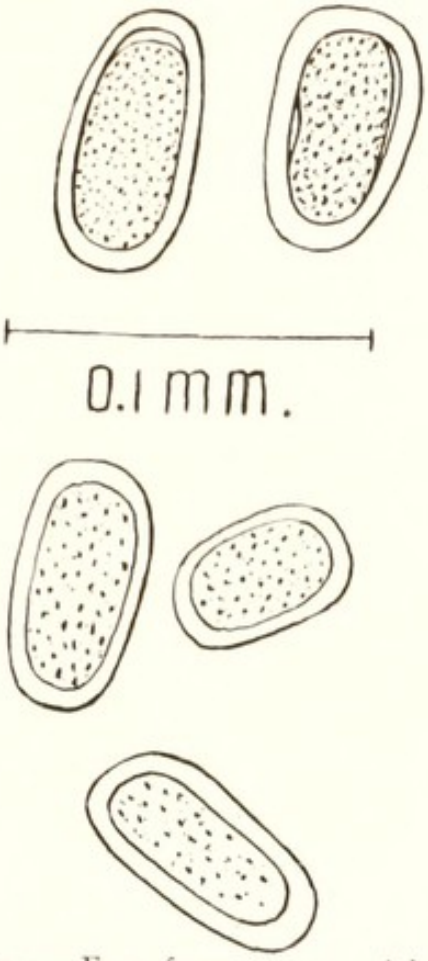

Fig. 62. *Heterakis papillosa.* Eggs from uterus. Adapted from Lane, 1918.

C. contorta (duck; esophagus and crop), 48 to 56 by 21 to 28 (Fig 63); C. anatis (goose; intestine and ceca), 42 to 46 by 24 to 25; C. dujardini

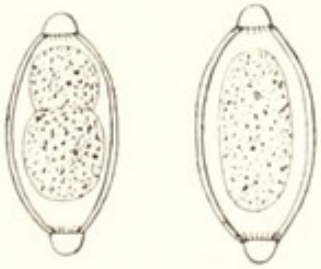

Fig. 63. *Capillaria contorta.* Eggs. x 300. From Railliet, 1893.

(pigeon; intestine), 53 to 56 by 28 to 32; C. strumosa (chicken; esophagus and trachea), 60 to 66 by 28.

The eggs of the following nematodes are somewhat oblong and truncated and have tuberculated or pitted shells: Hystrichis tricolor (duck; esophagus and proventriculus), 85 to 88 by 36 to 40; Eustrongylides elegans (duck; esophagus and proventriculus), 60 to 70 by 33 to 38 (Fig. 64); E. tubifex (duck; intestine), 65 to 75 by 44;

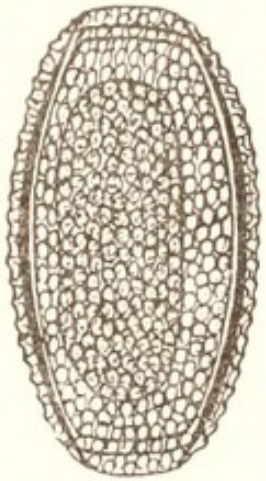

Fig. 64. *Eustrongylides elegans.* Egg. Enlarged. From Jägerskiöld, 1909.

E. papillosus (duck, goose; esophagus), 68 by 36.

The eggs of the echinorhynchs or thorny-headed worms of birds are elliptical and thick-shelled, similar to those previously described for such worms from other domesticated animals. Two species of echinorhynchs which occur in the intestine of the duck, goose and

Fig. 65. *Filicollis anatis.* Egg. x 340. From Luehe, 1911, after Marval.

swan are Polymorphus minutus, with eggs 91 to 110 microns long by 26 to 30 microns wide, and Filicollis anatis (Fig. 65), with eggs 56 to 60 microns long by 26 to 30 microns wide, according to some writers, or 62 to 70 microns long by 19 to 23 microns wide.

Spurious Parasites in the Feces of Animals

A SPURIOUS parasite may be defined as anything which is not a true parasite, at least in the host in which it is found, but which has been regarded as a parasite in that host or which may be mistaken for a parasite of that host.

Some of these spurious parasites are true parasites of hosts other than the one in which they are found; thus Oxyuris compar, reported by Leidy from the small intestine of the cat, is probably O. ambigua

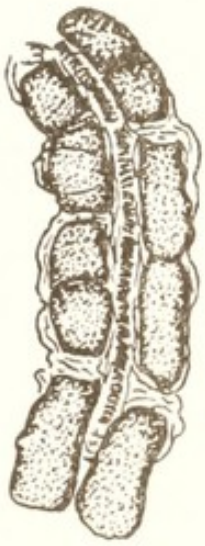

Fig. 66. Dark fibre cells of banana, showing arrangement resembling tapeworm strobila. Enlarged. From Stiles and Hassall, 1902.

from the large intestine of the rabbit, the cat having eaten the rabbit intestine a short time before the death of the cat and of the finding of the worm in the small intestine postmortem.

A second group of spurious parasites is composed of non-parasitic animals which have been eaten and subsequently found in the digestive tract or feces of the animal which ate them; thus various insect larvae

have often been regarded as parasitic, though many such cases deal with insects incapable of such parasitism and often found to be dead

Fig. 67. Seed of Indian mustard, *Brassica juncea*. Enlarged. From Beal, 1910.

and partly digested when carefully examined.

A third group of spurious parasites consists of portions of the host

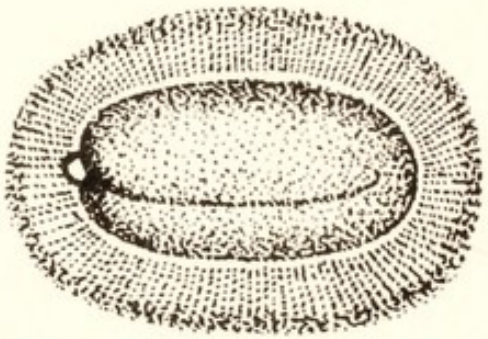

Fig. 68. Seed of shepherd's purse, *Bursa bursapastoris*. Enlarged. From Beal, 1910.

structure, such as ciliated tracheal cells which have been regarded as causative organisms in whooping cough, or lymphatic glands and

Fig. 69. Seed of daisy fleabane, *Erigeron ramosus*. Enlarged. From Beal, 1910.

pacchionian bodies which have been regarded as hydatids.

A fourth group of spurious parasites, and one of especial interest

Fig. 70. Seed of bird's foot trefoil, *Lotus corniculatus*. Enlarged. From Beal, 1910.

in connection with spurious parasites in feces, is composed of plant and animal material which may be mistaken for parasites and parasite

eggs. Plant material is especially likely to be mistaken for parasites owing to its greater content of indigestible substances as compared with animal material. Aside from bones, which are usually readily recognizable, there is comparatively little in the way of animal material which passes the digestive tract undigested, but the high content of cellulose and related substances in plants furnishes an abundance of

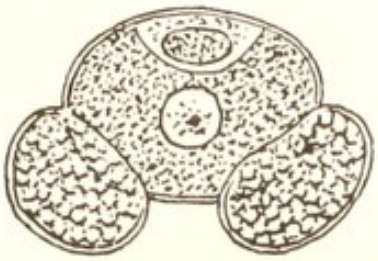

Fig. 71. Pollen-spore of a pine, *Pinus insignis*. Enlarged. From Campbell, 1902.

undigested materials which may simulate parasites, and numerous seeds and spores simulate parasite eggs.

Among the objects commonly present in feces and frequently mistaken for parasites are plant hairs. These are usually mistaken for nematodes of some sort, the hair being somewhat pointed at its free end and sometimes having a structure slightly suggestive of a strongyle bursa at the end originally attached. The writer has known these hairs to be mistaken for nematodes by a man of several years

Fig. 72. Cell of yeast fungus, *Saccharomyces cerevisiae*, containing 4 spores. Enlarged. From Campbell, 1902, after Reess.

experience in the field of parasitology and has called attention to one case in which such a plant hair was reported as a trichina larva in the blood. The homogeneous structure of these hairs and the lack of any internal structures resembling those in nematodes should be sufficient to distinguish them from worms. Fibrous connective tissue may sometimes be mistaken for nematodes, but here also the lack of

any internal organization resembling that of nematodes enables one to differentiate these structures. Numerous structures belonging to the fibro-vascular bundles of plants may simulate nematodes, but the presence of a spiral marking throughout or of regularly pitted markings along a cylindrical structure is suggestive of plant material. In case of doubt, always examine the object for the internal structure which should be present if it is a nematode.

Various substances simulate tapeworm segments. One which was reported years ago by Stiles and subsequently by various writers, and which the writer has seen on several occasions, consists of banana fibres (Fig. 66), which may have an arrangement very similar to a small tapeworm. Blanchard has noted a case in which a piece of peach skin was determined as a fragment of hydatid cyst.

Fig. 73. Ripe spores of corn smut, *Ustilago maydis*. x 600. From Campbell, 1902.

Of the things which may resemble flukes the pulp vesicles of the lemon and orange deserve mention. Pulp vesicles of the lemon are commonly present in lemonade and may pass intact in the feces of persons who have recently drunk lemonade. The superficial resemblance of these vesicles to flukes has been mentioned by a number of writers, including Leuckart, Stiles and Ransom, in connection with cases of mistakes in identification of parasites. The lack of any internal structure in any way resembling that of a fluke should be sufficient to prevent one from mistaking pulp vesicles for flukes. Careful washing to remove fecal matter, mucus, etc., is a great aid in determining the true nature of supposed parasites. As a matter of fact, such mistakes in identification are usually made as a result of total unfamiliarity with parasites or as a result of snap judgment.

The spurious parasites which are of most practical importance are the numerous objects, mostly plant material, which occur in feces and which resemble parasite eggs. To differentiate such material several tests may be applied. Such spurious parasites are frequently very different in size from the eggs which they resemble, and an accurate measurement will often show that they are not the eggs they are supposed to be. Plant material as a rule is more dense, more often colored, and shows less cell structure internally than do parasite eggs. Cestode eggs may be definitely determined by the presence of the 6 hooks of the onchosphere. Fluke eggs usually show an operculum or lid at one end. Nematode eggs are very variable in size and shape,

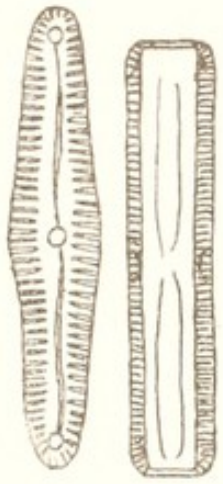

Fig. 74. Two views of the diatom *Pinnularia viridis*. Enlarged. From Campbell, 1902.

but they usually contain an embryo or else cells in process of division, and the shell is definitely delimited from the egg content to an extent which is not true of the external coat and the content of a plant spore. In a general way it is true here as elsewhere that other things may look like the thing you are in search of, but the thing itself is unmistakable when you find it. A parasite egg is evidently a parasite egg; it doesn't merely look like a parasite egg. Doubtful eggs are usually to be regarded as not eggs. As a final test of the matter one may sometimes use chemical reagents to differentiate plant material from animal material. The addition of tincture of iodin to a slide will color starches blue. By adding sulphuric acid and iodin cellulose sub-

stances will be colored violet or black, and nematode eggs will be colored black with a light areole where the shell shows at the periphery. Various stains have been used to stain plant material and leave worm eggs standing out against a stained background. Among

Fig. 75. A diatom, *Navicula sp.* x 500. From Campbell, 1902.

these stains are magenta, used by Giles, methyl green, used by Looss, Orange-G, used by Taylor, and gentian violet, used by Fauntleroy and Hayden. It is rarely necessary to resort to such elaborate technic to determine whether material is parasitic if one has been properly in-

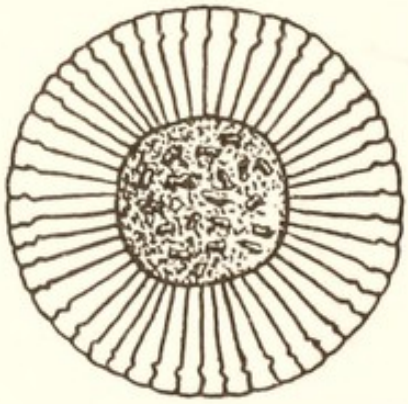

Fig. 76. A pelagic diatom, *Planktoniella sol*, viewed from above. x 125. From Campbell, 1902, after Schuett. This is actually disk-shaped.

structed in the subject of making fecal examinations, but when one must learn the art unaided, such devices are sometimes of value.

There should be little occasion to confuse the seeds of the higher plants with parasite eggs, as the seeds are usually much larger and are densely opaque. A distinctive structure of seeds is the micropyle, the aperture at which the young plant starts to grow from the seed. However, such confusion does arise and the Veterinary Record for October 3, 1914, reports a case in which small brownish objects in the feces of a patient were regarded as parasite eggs and subsequently found to be vanilla seeds, the patient being accustomed to drinking a

certain brand of cocoa which was found to contain such seeds. Strawberry seeds are frequently mistaken for parasitic material. As illustrations of the superficial resemblance between seeds and parasite eggs, there are figured here the seeds of Indian mustard (Fig. 67), superficially resembling an ascarid egg of some sort; the seed of shepherd's purse (Fig. 68), which if cleared to show this structure might resemble

Fig. 77. A division stage in a gonidium of one of the green algae, *Pleodorina californica*. Enlarged. From Campbell, 1902, after Shaw.

an echinorhynch egg or a nematode egg; the seed of the daisy fleabane (Fig. 69), which in outline is very similar to a whipworm egg; and the seeds of the bird's foot trefoil (Fig. 70), to show the micropyle characteristic of seeds.

A related body which is often found in feces in the spring is the

Fig. 78. A unicellular plant, *Chlorococcum sp.*, the one on the right showing division. x ca. 1000. From Campbell, 1902.

pollen-spore of the pines, this pollen being distributed in clouds on a windy day and occurring over wide areas about pines. The pollen-spore (Fig. 71), has a 3-part structure, consisting of a central body and 2 wings, and is practically unmistakable.

Various fungi produce cells or spores which call for some consideration as to identity the first time one sees them in feces. As

illustrations there are figured here a cell of the yeast fungus (Fig. 72) and some ripe spores of the corn-smut (Fig. 73).

Unicellular plants, belonging to the large group of algae, are frequently found in feces owing to their occurrence in water supplies of domestic animals. Some of these are figured here. Two of the diatoms figured (Figs. 74 and 75) have somewhat the outline of whipworm eggs, but have a quite different internal organization and have

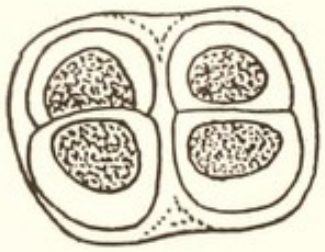

Fig. 79. One of the Schizophyceae, or blue-green algae, *Chroococcus turgidus*, showing 4 cells surrounded by a gelatinous envelope. x 500. From Campbell, 1902.

the distinct and delicate striation which is characteristic of the diatoms; the other diatom (Fig. 76) has a slight resemblance to the well known figures of the bothriocephalid tapeworm egg, but this diatom is flat, whereas the tapeworm egg is almost spherical. Various cells of algae are figured as figures No. 77, 78, and 79 to show the superficial resemblance of these cells to parasite eggs. The presence of chlorophyll in most of the algae is sufficient to distinguish them from parasite eggs.

Among the confusing objects which may be mistaken for worm eggs are the eggs of parasitic or free-living mites. They are especially likely to occur in the feces of mangy animals. These eggs (Fig. 16) are usually larger than most worm eggs.

Anthelmintic Medication for Worms Outside of the Digestive Tract

THE term anthelmintic is usually applied to drugs intended to destroy worms in the lumen of the digestive tract, but it may also be applied to drugs intended to destroy worms in the lumen of other organs, such as the air passages of the lungs, or to worms in various tissues, including the blood, or in cavities, such as the peritoneal cavity. This latter group of anthelmintics has been discussed in a paper by Ransom and Hall (1912). As yet we have but few drugs of value against worms situated outside of the lumen of the digestive tract, and but few worms are as yet known to be susceptible to successful attack by these drugs.

The cases in which worms not in the lumen of the digestive tract are amenable to anthelmintic treatment may be briefly summarized as follows:

LIVER FLUKE MEDICATION

The liver fluke of sheep may be successfully removed by means of male fern and its derivatives and to a lesser extent by kamala and its derivatives. The male fern treatment, which has received recognition in practice in Europe only during the last few years, was first proposed by Grassi and Calandruccio (1884; 1885) almost 40 years ago. It was favorably reported on by Perroncito (1885; 1886), all of these Italian authorities detailing experiments which showed the value of the treatment in killing flukes. Over 20 years later, another Italian, Alessandrini (1908), reported experiments showing that male fern would kill flukes, and 3 years later Borini (1911) reported success with this drug against the liver fluke in sheep and

cattle. This same year, French investigators, Railliet, Moussu and Henry (1911), confirmed the finding of the Italian investigators. Following this, male fern derivatives were marketed as proprietary remedies by French, German and Hungarian firms. Floris (1907; 1908) reported that carbon bisulphid is effective in removing **Fasciola hepatica,** but no one appears to have investigated his claims. Marek (1916) came to the conclusion that kamala was more effective in destroying liver flukes than was male fern, but later (Marek, 1917) he concluded on the basis of further experiments that the best treatment for liver flukes was by means of the administration of male fern derivatives in lipoid solution. Such a lipoid-soluble preparation is now being marketed in Europe. The efficacy of male fern and kamala against **Fasciola hepatica** evidently depends on the blood-sucking habit of the fluke, as the lancet fluke, **Dicrocoelium dendriticum,** which also occurs in the bile ducts, but is not a blood-sucker, is not affected by these drugs. According to Marek (1916), the active phloroglucin derivatives of male fern and kamala are absorbed in the intestine and carried to the liver in the portal circulation, and are there taken in by the liver flukes as they feed on blood.

BLOOD FLUKES IN MAN

The human blood flukes, more especially **Schistosoma haematobium,** but apparently **S. japonicum** and **S. mansoni** also, may be destroyed by anthelmintic treatment. According to Cawston (1921), **S. bovis** may be destroyed in the same manner. Joannidès (1911) reported injections of salvarsan as curative in 8 cases, but Conor (1911), Fuelleborn and Werner (1912), and Day and Richards (1912) have been unable to confirm his findings. Diamantis (1917; 1918) found emetine of value in destroying blood flukes, and though his findings were not substantiated by Morel and Maldonado (1918), they have since been substantiated by the work of Mayer (1918), Erian (1918), Balfour (1920), Day (1921), Tsykalas (1921) and others in thousands of cases. This drug, emetine, has been given intravenously, subcutaneously and intramuscularly in the treatment of

venal distomiasis. Christopherson (1918) proposed the use of tartar emetic intravenously for the treatment of this disease, this drug having been used previously in intravenous injections for the treatment of rats infested with the trypanosomes of nagana and surra by Plimmer and Thompson (1907), of sleeping sickness by Broden and Rodhain (1908), for American leishmaniasis by Vianna and Machade (1913), and for Mediterranean and Indian leishmaniasis by other workers subsequently. Christopherson's findings in regard to the value of the treatment in venal distomiasis were confirmed by the findings of McDonagh (1918), Wiley (1918), Low (1920), Cawston (1920-1921), Christopherson and Newlove (1921), Day (1921), Lasbrey and Coleman (1921) and others. Cawston (1921) finds that both emetine and tartar emetic are effective against **Schistosoma haematobium S. mansoni** and **S. bovis.** Day (1920) believes that emetine is indicated in preference to tartar emetic for small children, persons with veins too small to inject readily, persons intolerant of tartar emetic, those in whom an error of technic has resulted in abscess formation and in cases complicated by amebiasis. He also finds colloidal antimony effective and to be preferred to tartar emetic for treating children. Cawston (1921) prefers emetine to tartar emetic for children and young persons. Recently, Wilson (1922) has reported favorably on the rectal administration of tartar emetic, a method which saves time, is free from risk, and causes less nausea and vomiting. The drug is absorbed by the veins of the intestine, thereby coming in contact with the worms in the blood.

VALUE OF MEDICATION NOT KNOWN

Little is known as yet with regard to the value of anthelmintics against other flukes outside of the lumen of the digestive tract. According to a review, Ando (1918) has had good results in the treatment of infestations with the lung fluke, **Paragonimus westermani,** by means of tartar emetic, but no details of these studies are available to us. Low (1920), believes that this drug will be of value against **P. westermani, Clonorchis** and other flukes, but evidence in regard to such efficacy appears to be lacking as yet. It may be sur-

mised that where flukes lie in the blood, as do the blood flukes, or feed on blood, as does **Fasciola hepatica,** anthelmintic treatments for their destruction will probably be developed, but that flukes which are encysted, as **P. westermani** or **Agamodistomum suis,** or which do not feed on blood, as **Dicrocoelium dendriticum,** will be distinctly more difficult to destroy by anthelmintic treatment, though the possibility of accomplishing their destruction in this way is by no means out of the question. **D. dentriticum** might be amenable to anthelmintics eliminated in the bile.

CESTODE MEDICATION

In the case of cestodes outside of the lumen of the digestive tract, little has been accomplished as yet in the way of anthelmintic treatment. For the most part, such cestodes are larvae encysted in tissues, and while the growth of these larvae shows that they absorb solid and fluid material from their host, the growth is slow and it is evident that the absorption is very slow, a feature which promises little for the success of anthelmintic treatment. Zürn (1882) was unable to find a drug that would destroy the gid parasite in the brain of sheep in the course of 24 years' experiments along this line. Hall (1909) and Moussu (1910) found repeated doses of male fern ineffective in gid in sheep, the parasites being found alive after the conclusion of the treatment. Feletti (1894), de Renzi (1908) and Dianoux (1909) have reported cures of a total of 6 cases of cysticercosis in man following repeated doses of male fern. Moussu (1910) was unable to cure a similar case of cysticercosis in a pig by this treatment. De Renzi (1908) reported the cure of 2 cases of hydatid disease in man by the administration of repeated doses of male fern, but Dévé (1911) was unable to obtain similar results in cases of hydatid infestation in rabbits. Dévé and Payenneville (1914) found repeated injections of neosalvarsan intravenously of no value in preventing the development of hydatids in rabbits. Recently, Dévé and Payenneville (1922) have reported the same negative results with novarsenobenzol.

Of the adult cestodes occurring outside of the lumen of the digestive tract, we find such forms as **Thysanosoma actinioides** in the bile ducts. Curtice (1889; 1890) was unable to find a satisfactory treatment for these worms in tests with pumpkin seed, pomegranate-root bark, koosoo, kamala, male fern, and worm seed. Stiles (1902) found arsenic of no value against fringed tapeworm. Ransom and Hall (1912) were unable to destroy these fringed tapeworms by means of repeated doses of carbon bisulphid or of male fern.

The findings in many of the cases dealing with the treatment of intestinal and of somatic taeniasis are somewhat vague or uncertain and it is necessary to reserve judgment in these cases as regards the efficacy or inefficacy of the treatment. Undeniably the results obtained in attempts at treatment to destroy tapeworms outside of the lumen of the digestive tract are inferior to those obtained in the case of certain flukes. Probably these tapeworms are less susceptible to anthelmintic treatment than are the flukes in question, but more work is necessary along this line.

NEMATODE MEDICATION

The nematodes outside of the lumen of the digestive tract, like cestodes so situated, are less amenable to anthelmintic treatment than are the trematodes. The reason for their resistance does not appear to be the same as in the case of cestodes. Many of these nematodes are not encysted and some of them must feed on blood or lymph. While the nematode cuticle may be thought to be more resistant than the corresponding structure in flukes or tapeworms, it must be borne in mind that certain drugs will destroy nematodes in the lumen of the digestive tract in cases where the same drugs entirely fail to show any adverse effect on flukes or tapeworms similarly situated. The reverse of this is, of course, true. It appears, therefore, that we must consider the action of anthelmintics as more or less specific and that the question of penetration is of little moment, whereas the finding of a suitable drug is of prime importance. In a general way it may be said that other things being

equal it is no more difficult to remove or destroy one kind of worm than to remove or destroy any other kind. With a suitable drug the removal or destruction is easy; without such a drug it is difficult or impossible. The present literature on the treatment of infestations with nematodes outside of the lumen of the digestive tract has little in the way of definite positive results to record as yet and can only be briefly summarized here.

TREATMENT OF TRICHINOSIS

In the treatment of trichinosis, recommendations of various drugs have been made largely on the basis of clinical improvement or cure, without reference to whether the worms present in the muscles were affected or not affected by the drug. On such a basis McNerthney thymol of value when given subcutaneously or intramuscularly in repeated doses, and Rosique (1917) found grey oil of value. But Eisenhardt (1918) found that thymol did not prevent the development of trichinae, and Romanovitch (1912) found salvarsan devoid of action. In trichinosis there are several factors present, and a given treatment may leave the larval worms in the tissues unaffected and at the same time aid the patient by the elimination of adult worms from the lumen of the intestine, by neutralizing toxins, etc. As an illustration it may be noted that Salzer (1916) found the use of serum from recovered patients valuable in the treatment of other patients and claimed that the use of such a serum in animals would prevent the development of trichinosis. Schwartz (1917) tested these claims and found that trichinae would develop in animals regardless of the use of serum. Hall and Wigdor (1918) also carried out tests along this line and although they confirmed Schwartz's findings to the effect that trichinae would develop in spite of the use of serum, they found that treated animals usually lived longer than untreated animals. They concluded that the serum of animals which had recovered from trichinosis probably had anti-bodies which were of service in neutralizing certain worm toxins responsible for part of the pathological conditions. Von Linden (1917) claims that severe trichinosis can be prevented in guinea pigs and rabbits by feeding them copper preparations, check

animals becoming heavily infested. This claim requires confirmation. At the present time we know of no drug that has been definitely ascertained to kill trichinae in the muscles.

TREATMENT OF FILARIDS

Aside from trichinae, the worms which have received the most attention from the standpoint of medicinal treatment are the filarids. The papers on this subject do not indicate that much of a definite and positive nature has yet been established. Schultz has reported success in killing the adult **Loa loa** in the connective tissue of man, together with the larvae in the blood, by the administration of a 1 per cent solution of collargol in dessertspoonful doses three times a day for over a year. Thiroux and d'Anfreville (1910) report the disappearance of **L. loa** in a patient treated with aniline tartrate. Morlot and Zuber (1914) report the disappearance of this worm following injections of neosalvarsan. Rogers (1919) and Das (1920) have reported favorably on tartar emetic in infestations with **Filaria bancrofti,** but Low and Gregg (1920), Macfie (1920) and Low and O'Driscoll (1921) report unfavorably on this drug, Macfie's cases including infestations with **F. bancrofti, F. perstans** and **L. loa**. Low and O'Driscoll found emetine also ineffective, and though Mühlens (1921) has seen filariae disappear from the blood after emetine, he regards this as spontaneous or accidental, another case showing no results after emetine, tartar emetic and neosalvarsan. Siebert (1920) found that filariae disappeared in the case of an undetermined species of filarid after treatment with picric acid and refers to Scheube (1910) as having seen the microfilariae of **F. bancrofti** die in the blood after the administration of potassium picrate. Ikegami (1920) reported that after 2 injections of arsaminol (Japanese salvarsan) in the case of one patient, the microfilariae disappeared from the blood and the urine became clear; no chyluria or other symptoms reappeared in over a year. Curasson (1920) reports that he treated 3 carrion

crows of Senegal, all harboring microfilariae in the blood, with injections of galyl. The microfilariae disappeared from one bird for 9 days and then reappeared; no adult worms were found postmortem. The microfilariae became rare and less active in the second bird; 2 adult worms were found dead in the abdomen postmortem. No microfilariae were found in the third bird for 12 days; 1 worm, aparently dead, was found in the abdomen postmortem. Macfie (1920) treated 23 patients infested with Guinea worm, **Dracunculus medinensis,** by means of intravenous injections of tartar emetic; the worms and embryos died and could either be extracted safely or allowed to become absorbed. Jeanselme (1919) Montpelier and Ardoin (1919), and Grey (1920) report similar good results in infestation with Guinea worm from the use of injections of novarsenobenzol.

The foregoing indicates that as yet we lack adequate evidence establishing any drug as effective in the treatment of cases of infestation with **Filaria bancrofti;** that we may have a satisfactory treatment for **Loa loa,** though more work must be done to establish this; and that we apparently have satisfactory treatments for **Dracunculus medinensis**.

In a paper read before the last meeting of the American Veterinary Medical Association, Hall and Shillinger reported some tests of intravenous injections of carbon tetrachlorid and of tartar emetic for the destruction of **Strongylus vulgaris** in aneurisms in horses While these tests were inconclusive, the finding of a dead worm in an aneurism in one case suggests that further work along this line might result in the development of a satisfactory treatment for the destruction of these worms.

We have as yet no well established treatment for lungworms, in spite of the many treatments reported in the literature, and at the present time nursing treatment, isolation of sick animals, and the provision of safe and proper food and water supplies are apparently the best lines of treatment.

Anthelmintic Medication for Parasites in the Lumen of the Digestive Tract

In a previous paper the writer has summarized, in a general way, our knowledge of anthelmintics for the control of worms outside of the lumen of the digestive tract of man and animals, the definite knowledge on that subject in the fields of human and veterinary medicine not making a total too large for brief consideration in one article. In this paper the subject of drugs for the removal of parasites from the lumen of the digestive tract will be considered, primarily with reference to their use among domesticated animals, with little consideration of the rather large subject of anthelmintics used in human medicine to remove parasites from the lumen of the digestive tract.

We have at the present time quite satisfactory treatments for the removal of many of the common parasites of the digestive tract, the treatments in some cases being established by critical tests and the tests subsequently supported by clinical experience, and in other cases being established by clinical experience and clinical experience subsequently supported by critical tests. On the other hand, there are a number of parasites for which we have as yet no satisfactory treatment, notably the spirurids living partly in the lining and partly in the lumen of the digestive tract, and the tapeworms of birds.

FASTING

In administering anthelmintics by mouth, it is customary to fast the animals to be treated in order to diminish the amount of ingesta in the digestive tract, this ingesta acting as a diluent for the anthelmintic and also affording mechanical protection to worms in some instances The length of the preliminary fast varies with the nature of the host animal and the location of the worm. A fast of 18 hours has been

found to be adequate as a preliminary to treating horses for bots, but it seems necessary to fast a horse 36 hours in order to obtain satisfactory results in treating to remove strongyles from the large intestine. The directions given in regard to fasting should, therefore, be observed. Additional information is needed in some cases as to the length of the fast to be observed, but the directions are as accurate as it is possible to make them in the present state of our knowledge and in many cases a different fasting period, especially a shorter one, is known to give inferior results. Animals may be watered soon after treatment, but should not be fed for two to three hours, as feeding immediately after treatment defeats the purpose of the preliminary fasting.

MASS TREATMENTS VERSUS INDIVIDUAL TREATMENTS

There is always a demand for mass treatments where large numbers of animals are to be treated, and this demand is not limited to the farmer but includes some veterinarians. It is a very natural demand, since the individual treatment of large numbers of animals, especially those where the value of the individual animal, such as a chicken, is low by comparison with the larger domesticated animals, requires a disproportionately large amount of time in the aggregate. The farmer feels that the benefits derived from a treatment of this sort in such cases do not compensate for the expense incurred in paying a veterinarian for such treatments—and in some cases this would be true. For practical purposes, therefore, we may use mass treatments where a certain degree of benefit may be expected and where individual treatments, which would be more beneficial, cannot be used owing to the time and cost factors.

Mass treatments are usually in the nature of treatments by means of substances added to the feed. Animals are usually fasted before such treatments, but the fasting is not for the purpose of emptying the digestive tract, as a rule, so much as to make the animals hungry enough

to eat food to which some more or less unpalatable anthelmintic has been added. The presence of the food distinctly diminishes the efficacy of the anthelmintics, but there is usually some anthelmintic action with suitable drugs and as the food dilutes the anthelmintic and in this way, as well as mechanically, probably protects the mucosa of the digestive tract against irritant action and retards absorption to some extent, somewhat larger doses of the drug may be tolerated than would be tolerated by a fasting animal which was not given feed with the drug. On the other hand, it must be remembered that where a drug is mixed with the feed for a number of animals, some animals will eat more than others, and perhaps get more of the drug than can be well tolerated, whereas other animals will find the drug too distasteful and will get too little to be of value. The animals which eat little or none of the medicated feed may be the ones which are most in need of treatment. Mass treatments are most used in the case of poultry, the animals having the smallest value per head and the ones which are kept in the largest numbers as a rule. Chickens and swine are probably the most difficult to catch of the domesticated animals, and swine are probably the most difficult to treat, these things accounting in part for the demand for mass treatments for these animals.

COMPLICATIONS DUE TO LARVAL WORMS PRESENT

In a paper on the treatment of horses for the removal of worms the writer has called attention to the fact that there are many cases in which worms, especially certain nematodes, migrate through the body of the host or develop in certain tissues for days, weeks or months, and that although anthelmintics may remove all of the adult worms present at the time of treatment, these larval or agamic worms may enter the lumen of the digestive tract soon after treatment and be found there, sometimes, in the case of horse strongyles for example, as mature worms very soon after treatment. At present the only action that can be taken in this connection is to repeat treatment at

such intervals as the life history of the worms indicates as appropriate, or as the clinical condition of the animal calls for it, or as the recurrence of eggs in the feces shows the recurrence of infestation.

PERIODS DURING WHICH WORMS ARE PASSED

The impression is quite prevalent that almost all worms passed after an anthelmintic come away in the first 24 hours after treatment. This is not the case. They commonly come away for two or three days, and bots may pass for over 17 days after treatment. It is therefore unsafe to conclude that a treatment is a failure because worms did not come away during the first day after treatment. In the treatments given in this paper there is a statement as to the length of time worms have been observed to pass after treatment wherever such information is available. It is quite probable that worms come away under some circumstances for even longer periods than those given.

EXAMINATION OF FECES FOR WORMS PASSED

Worms embedded in a fecal mass are easily overlooked, especially by persons unfamiliar with worms. The careful veterinarian will disregard the statement of the farmer, stable hand or dog owner who assures him that no worms were passed after treatment. A glance at the feces or a casual poke with a stick or straw cannot be depended on to give accurate information. The most satisfactory method of examination is to screen the feces through a screen of suitable size to retain the worms, washing as much fecal matter as possible through the screens, and then examining the screen. If this cannot be done, the feces should be thoroughly picked apart in a good light and carefully examined.

TREATMENTS FOR HORSE PARASITES

Bots: Fast 18 hours. For a 1000-pound horse, carbon bisulphid in capsules; 1 dose of 22 cc. (6 fluid drams); or 2 doses of 15 cc. (4 fluid drams) each with a two-hour interval between doses; or 3 doses of 11 cc. (3 fluid drams) each with an hour interval between doses. No

purgation; oil immediately following treatment especially contraindicated. Bots pass for over 17 days. Efficacy, approximately 100 per cent. Carbon tetrachlorid in 25 to 50 cc. doses is approximately 25 per cent effective in removing bots. Other drugs are ineffective.

Ascarids: The same treatment as for bots. Oil immediately following treatment contraindicated. Worms may pass for several days. Efficacy approximately 100 per cent for carbon bisulphid and apparently the same for carbon tetrachlorid.

Palisade worms (Strongylus spp.): Fast 36 hours. Oil of chenopodium, 16 to 20 cc. (4 to 5.3 fluid drams) in capsule, followed immediately by one liter (approximately one quart) of raw linseed oil or by aloes ball. Worms may pass for six days or more. Efficacy, 95 to 100 per cent.

Another treatment: Fast 36 hours. Oil of turpentine, 64 cc. (two fluid ounces), in capsule, followed immediately by a liter of raw linseed oil or aloes ball. Efficacy (ascertained on one animal only), approximately 50 per cent.

Another treatment: Carbon tetrachlorid, 25 to 50 cc. (6.5 to 13 fluid drams), in capsule. No purgation. Efficacy, 100 per cent.

Cylicostomes: The same treatment as for palisade worms. Worms pass for six to twelve days. Efficacy, approximately 100 per cent for chenopodium and oil of turpentine; variable for carbon tetrachlorid—from 100 per cent to less than 50 per cent.

Pinworms: Oil of chenopodium or turpentine as for palisade worms. Worms pass for two days. Efficacy, 100 per cent.

Stomach worms (Habronema spp.): Uncertain. It is probable that carbon bisulphid, carbon tetrachlorid, oil of chenopodium, and possibly turpentine and other drugs will kill the worms in the lumen of the stomach, but it is difficult to obtain evidence on this subject as worms killed in the stomach are probably digested as a rule. The worms embedded in the mucosa or buried under mucus appear to be adequately protected against the action of these and other known

anthelmintics. It has been found by Hodgkins that numbers of these worms may be washed out of the stomach by gastric lavage with the stomach tube. Possibly anthelmintics could be effectively administered in this way. In some cases repeated treatments by mouth or by lavage might remove all or practically all of the worms present.

To clean out the bots and nematode parasites as completely as possible from the digestive tract of the horse, give the carbon bisulphid treatment for bots and ascarids and two weeks later give the chenopodium treatment for palisade worms, cylicostomes and pinworms. Both drugs will probably kill stomach worms not protected by mucus or in the mucosa.

Tapeworms: The presence of tapeworms in the horse is usually ascertained postmortem and practically nothing is known in regard to treatment. As the worms occur in the stomach, small intestine and large intestine, it would require critical tests, which have not yet been made, to determine the efficacy of drugs against these worms with any degree of accuracy. The indicated drugs for test are those in common use against tapeworms, such as oleoresin of male fern, kamala, etc.

TREATMENTS FOR CATTLE PARASITES

Ascarids: Treatment uncertain as we lack the findings of critical tests of anthelmintics for removing these worms. Hornby finds turpentine in doses of two to four fluid drams in a mixture of two fluid ounces of linseed and castor oils effective when this dose is given on each of two successive morning to calves and a third dose is given a week later. A single dose of two drams is ineffective and one ounce is too toxic.

Stomach worms (Haemonchus contortus): The copper sulphate solution and the tobacco and copper sulphate solution noted below in connection with stomach worms of sheep are probably of some value in controlling stomach worms in cattle when given in appropriate doses, 100 to 300 cc., but in the absence of critical tests we cannot make very positive statements in regard to this. Carbon tetrachlorid in doses of 100 cc. to calves weighing 80 and 114 kilos (175 and 250 pounds) removed all the stomach worms, but had a toxic effect on the animals, the smaller one being dead the fourth day. Adult cattle have succumbed to doses of 22 cc., but good clinical results are reported from doses of 32 cc. (one fluid ounce) of carbon tetrachlorid in one pint of

olive oil for animals weighing 700 to 800 pounds, and in doses of half this amount of carbon tetrachlorid and olive oil for yearlings. At present we have too little evidence and experience on which to make recommendations.

Hookworms: The solution of copper sulphate and tobacco discussed in connection with stomach worms in sheep has been reported as effective against hookworms in sheep and might be effective against hookworms in cattle, especially in repeated doses. Carbon tetrachlorid, in the tests on calves referred to above, removed almost half of the hookworms from one calf and 99 per cent of those present in the other, each calf having hundreds of worms. As noted, the doses given were apparently too large and this subject requires more investigation. Marek has reported satisfactory results from the use of a proprietary composed of lipoid-soluble constituents of male fern.

Nodular worms: Csontos and Pataki report good clinical results from the use of the proprietary remedy referred to above as used by Marek against hookworms. Carbon tetrachlorid, in the tests of calves referred to above removed all the nodular worms from both animals. It is not yet known what dose will maintain this efficacy and at the same time be safe for cattle; the dose given above was too large for safety.

Small trichostrongyles: Nothing is yet known in regard to the removal of these worms from cattle, but carbon tetrachlorid has been found more effective against similar worms in sheep than any other drug yet tested and might prove effective here in suitable doses.

Tapeworms: The solution of copper sulphate and tobacco discussed under the heading of stomach worms of sheep is said to be very effective against tapeworms in sheep. In doses suitable for cattle, perhaps 100 to 300 cc., this treatment might also be effective against tapeworms in cattle.

TREATMENTS FOR SHEEP AND GOAT PARASITES

Stomach worms: Copper sulphate, one per cent solution in water, to animals fasted overnight; if used as a routine repeated treatment, animals need not be fasted. For sheep, 100 cc. (3.5 fluid ounces), for lambs, 50 cc. (1.75 fluid ounces.) No purgation. Worms pass for four days. Efficacy, 93 per cent as indicated on the basis of worms passed and worms present postmortem. As noted in connection with stomach worms in horses, many of the worms killed by anthelmintics in the stomach are digested there, and the check animals in stomach worm experiments on sheep indicate that many of the worms which are killed are digested and therefore not accounted for in the examination for worms passed; it seems certain that the copper sulphate treatment is much more than 93 per cent effective. It falls short of 100 per cent efficacy, but is probably close to 99 per cent effective. The doses which are given here may be repeated at intervals of three to four weeks throughout the year in places where stomach worms are prevalent, with decided benefits in the way of increased production of mutton and wool. The one per cent solution may be made up at the rate of one gram of powdered blue crystals of copper sulphate to 99 cc. of water, or, for large amounts, at the rate of one-fourth pound of copper sulphate dissolved in one pint of boiling water, with cold water added to this solution to make a total of three gallons, enough to dose 100 adult sheep and allow 10 per cent for waste.

Another treatment consists in using a solution containing one per cent copper sulphate solution and one per cent by weight of snuff or powdered tobacco. The tobacco is steeped in the water overnight and the copper sulphate then added. The dose and method of treatment is the same as for the copper sulphate treatment given above. The reported efficacy is 90 to 100 per cent; 90 is probably too low as noted above. See Addendum, page 92.

Carbon tetrachlorid in doses of 12 to 48 cc. in 60 cc. of castor oil has been found to remove all the stomach worms from infested sheep. The dose which is most satisfactory from the standpoint of efficacy and safety has not yet been ascertained.

A treatment reported favorably from South Africa consists in the use of a mixture of sodium arsenite (testing 80 per cent arsenious oxid), one part, and copper sulphate, four parts. Doses: Animals two to four months old, 0.18 gm.; four to six months, 0.25 gm.; six to ten months, 0.375 gm.; one year old, 0.5 gm.; two years old or older, 0.625 gm. This is given as a powder. Withhold food and water the afternoon before dosing; dose next morning; feed in afternoon; feed and water the next morning. Treatment may be repeated the day after the first dose, allowing feed the afternoon after the first dose, dosing the next morning, and feeding that afternoon, but allowing no water until the morning following the second treatment.

Hookworms: The solution of copper sulphate and tobacco administered in the same dose and manner as for stomach worms. Efficacy, on the basis of reported experiments (Guberlet), 100 per cent.

Carbon tetrachlorid in doses of 15 to 30 cc. in castor oil and in doses of four and eight cc. in capsules removed all the hookworms from four infested sheep. Worms pass for two days. Further investigations are necessary to ascertain the minimum effective dose and the best mode of administration.

Oil of chenopodium, one fluid dram (3.75 cc.) in five ounces (160 cc.) of milk has been found to remove about two-thirds of the hookworms from sheep. Worms pass for two days.

Nodular worms: No well established treatment. Carbon tetrachlorid in doses of 15 to 48 cc. removed from 3 to 100 per cent of the worms present. Further investigation necessary. Larval worms in nodules probably not amenable to any known treatments.

Small trichostrongyles (Nematodirus, Cooperia, Ostertagia and Trichostrongylus): Carbon tetrachlorid in doses of 12 to 48 cc. removed 82 per cent of these worms from four infested sheep. From two other sheep it removed 3 to 27 per cent. From two other sheep doses of 4 to 12 cc. apparently failed to remove any trichostrongyles of the genera named. This is the only drug yet reported as capable of removing these worms, but further investigations are necessary to determine the best dose and mode of administration. The drug seems especially effective against species of Nematodirus, these being blood-sucking forms and distinctly pathogenic.

Tapeworms: Copper sulphate and tobacco solution as for stomach worms. Efficacy, usually 100 per cent. Copper sulphate solution alone will remove some tapeworms.

Sodium arsenite and copper sulphate as for stomach worms.

Treatments which have been said to be effective, but concerning which we have no evidence from critical tests are: Kamala, one dram to lambs; kousso, two drams to lambs; koussin, two grain doses; oleoresin of male fern, one dram with two to four fluid ounces of castor oil; areca nut, freshly ground, one to three drams to lambs.

TREATMENTS FOR SWINE PARASITES

Ascarids: Fast 24, preferably 36, hours. Oil of chenopodium, one fluid dram (3.75 cc.) in or immediately preceded or followed by two fluid ounces (ca. 64 cc.) of castor oil for animals weighing 100 pounds (45 kilos). Diminish dose of chenopodium for small animals in proportion to weight, but use at least one ounce of castor oil; for larger animals the dose of castor oil should be increased, up to four ounces for very large animals. Chenopodium requires adequate purgation to offset its constipating and toxic action. In default of castor oil, which is bulky, it has been suggested that salts be given in soft feed of some sort three hours after treatment; no reports on the results

of such treatments are available. Worms pass for two days. Efficacy, approximately 100 per cent.

Santonin has for many years enjoyed the reputation of being the best ascaricide known, but critical tests show that in single therapeutic dose it is distinctly inferior to chenopodium for removing ascarids from dogs and swine. To develop its greatest efficacy it must be given in small doses repeated daily, and given in this way it appears to exert a cumulative action on the worms and is quite effective, a smaller total being more effective than a single dose larger than this total. Santonin and calomel, equal amounts, in doses of four to eight grains each, are commonly recommended for removing ascarids from swine, but chenopodium is better.

Dosing swine is difficult. If capsules are used, care must be taken to avoid placing them in the retropharyngeal recess or the trachea, as in either place they will cause serious or fatal results. If the capsules are placed only on the back of the tongue, swine usually eject them from the mouth sooner or later. It is feasible to use a speculum and pass a stomach tube; a horse catheter may be used as such a tube. Swine are noisy, dirty, hard to catch and hold, and can bite viciously, and these things, as already noted, account in part for the demand for "something to put in the feed" to remove worms from swine. However, experiments indicate that drugs placed in the feed are wasted for the most part, the anthelmintic efficacy falling off very seriously or being entirely lost.

Carbon tetrachlorid does not appear to be a very satisfactory anthelmintic for use in removing worms from swine. It is fairly effective in removing ascarids when given at a dose rate of 0.6 cc. per kilo, but this dose is much more bulky than that of chenopodium and is less effective. Furthermore, carbon tetrachlorid has a much smaller margin of safety for swine than for carnivores and poultry.

Stomach worms (Arduenna strongylina, Physocephalus sexalatus and Hyostrongylus rubidus): Oil of chenopodium as for ascarids. This drug mixed with castor oil and milk and given in feed removed about 60 per cent of the Arduenna present in an experiment animal, judging the efficacy from the worms passed and those left postmortem; worms passed for four days. As noted in regard to stomach worms in horses and sheep, probably some worms were digested after being killed and the drug was probably distinctly more effective than the fecal findings indicate. With this evidence as to the efficacy of the drug when given in feed, it seems safe to assume that it will be more effective when properly administered. The stomach worms which are protected by burrowing in the mucosa or which are embedded in a thick mucous coating may be and probably are protected from the action of anthelmintics.

Nodular worms: No satisfactory treatment known. The chenopodium treatment as given for ascarids will remove some nodular worms.

Thorny-headed worms: No effective treatment known as yet. Turpentine and copper sulphate have each been recommended, but we lack experimental evidence in regard to these drugs. Oleoresin of male fern has been found effective in a case of human infestation with one species of thorny-headed worms, not the species in swine, and would be worth trying against the swine parasites.

Tapeworms: Many writers give treatments for tapeworms in swine. For practical purposes, swine are not infested with adult tapeworms. The few reported cases of these worms in swine apparently deal with tapeworms of sheep or other animals, these tapeworms having been swallowed by swine in eating the intestines of the true host, or with tapeworms of animals other than swine which have undergone partial development in swine but have remained sterile in the unusual host.

TREATMENTS FOR DOG PARASITES

Ascarids: Fast overnight. Oil of chenopodium, 0.1 cc. per kilo (1 cc. to a 22-pound dog), in capsule, immediately preceded or followed by 32 cc. (one fluid ounce) of castor oil. Purgation important. Febrile conditions, such as distemper, or mange are contraindications for treatment. Dog is usually salivated and may vomit, but drug is usually effective in spite of vomiting. Worms pass up to seven days, coming away after treatment as follows: First day, 82.7 per cent; second day, 7.7 per cent; third day, 4.3 per cent; fourth day, 3.1 per cent. These are the figures for a large series of dogs. Efficacy, approximately 100 per cent.

Another treatment: Fast overnight. Carbon tetrachlorid, 0.3 cc. per kilo (3 cc. for 22-pound dog) in hard capsules. Purgatives may be given 2 to 3 hours later. Care must be taken not to get the drug into the lungs. Efficacy, 80 to 100 per cent. This drug is less effective for removing ascarids from dogs than is chenopodium, but it is also safer (therapeutic dose has an indicated safety factor of 53) and is preferable in the cases of patients that are very young, very old, feeble, or suffering from mange or febrile conditions. In general the drug can be given with safety to pups two weeks old.

Another treatment: Where there is inflammation of the digestive tract, santonin may be the drug of choice as it is not a gastrointestinal irritant. Carbon tetrachlorid would be the next choice under these conditions, chenopodium being distinctly irritant. Santonin should be given in doses of 0.5 to 1 grain daily, with an equal amount of calomel, for several days. Give early in the morning and do not feed dog for two to three hours after treatment.

Hookworms. The carbon tetrachlorid treatment as outlined for ascarids. Worms pass for four days. In a series of experiments with

various drugs, hookworms passed as follows: First day, 74.1 per cent; second day, 15.7 per cent; third day, 7.4 per cent; fourth day, 2.8 per cent. Efficacy of carbon tetrachlorid, approximately 100 per cent.

Whipworms. Santonin, 0.5 to 1 grain, with an equal amount of calomel daily, two to three hours before feeding in the morning, for one week. Suspend treatment for one week, and then repeat for a week. The results should be checked by examination of the feces for worms passed and for eggs persisting, to make sure of the results, but this makes a fairly satisfactory routine treatment where such examinations cannot well be made. The difficulty in removing whipworms is due to the fact that drugs do not always enter the cecum after passing the ileo-colic valve. Even relatively feeble anthelmintics will remove whipworms when they enter the cecum. Entrance into the cecum can be ensured to some extent by using repeated doses or very large doses. For repeated doses a non-irritant drug, such as santonin, is distinctly indicated. If large doses are to be employed, it is advisable to use a drug of low toxicity and a high safety factor, such as carbon tetrachlorid. Carbon tetrachlorid in one large dose, 1 cc. per kilo, will sometimes prove effective in removing whipworms. Strong animals will tolerate this dose or much larger doses, but it is inadvisable to use large doses of anthelmintics in the case of old, very young, or sick or weak animals.

Tapeworms. Fast overnight. Arecoline hydrobromid by mouth, ⅛ grain to small dogs; ¼ grain to dogs of average size. No purgative; the drug itself is purgative. Worms usually pass in half an hour, but tapeworms of the genus Dipylidium may pass for four days after tapeworm treatments, the worms in a series of experiments coming away as follows: First day, 91 per cent; second day, 7.4 per cent; third day, none; fourth day, 1.6 per cent. This tapeworm

treatment, developed by Lentz, has been highly recommended on the strength of clinical experience, but no critical tests have yet been published giving exact information in regard to its efficacy. No dosage for large dogs has yet been given, but it seems probable that the dose should be increased up to ½ grain for large dogs.

A treatment developed by Dr. E. T. Davison is as follows: Fast overnight. At 10:00 A. M., for dogs of average size, give four 10-grain capsules (those holding 10 grains of quinine) filled with oleoresin of male fern, and follow with an ounce of water or milk, preferably milk. Forty-five minutes later give four 10-grain capsules full of freshly ground areca nut. It is essential that the areca nut be freshly ground; after grinding it gradually loses its potency and finally becomes inert. Follow the areca nut with an ounce of milk or water as above. Worms usually pass in a half hour to an hour. After dosing tie the dog's head as high as it can be held without choking, to prevent vomiting.

Oleoresin of male fern, 3.75 cc. (1 fluid dram) in capsules, followed immediately by 32 cc. (1 fluid ounce) of castor oil, is highly effective against tapeworms. The theory that castor oil increases the toxicity of male fern is not supported by experience and experiments; critical tests show that castor oil is protective to a considerable extent against the toxic effects of male fern where the two drugs are given together.

Kamala, 2 to 8 gms. (0.5 to 2 drams) in syrup, is very effective against tapeworms.

Tapeworms of the genus Dipylidium, the double-pored tapeworms of carnivores, are difficult to remove entirely owing to the habit these worms have of sewing the head and the anterior portion of the strobila into the mucosa. Thus protected the worm may lose the posterior portion of the strobila from anthelmintic action, but the head will re-

main to renew the infestation. Treatments must be repeated as often as necessary. As fleas and lice are intermediate hosts, the removal of these worms should be accompanied by the eradication of the insect hosts or reinfestation usually follows in a short time.

Flukes. According to Jeffreys, carbon tetrachlorid as given above for ascarids will remove the intestinal flukes from foxes, and it may prove equally effective in removing these flukes from dogs.

TREATMENTS FOR CAT PARASITES.

Ascarids. Fast overnight. Oil of chenopodium, 0.05 cc. per kilo, immediately preceded or followed by a half ounce to an ounce of castor oil. Chenopodium is twice as toxic for cats as for dogs and should be used in the diminished dose given here. The carbon tetrachlorid treatment is safer.

Carbon tetrachlorid, 0.3 cc. per kilo, to animals fasted overnight, as for dogs. Carbon tetrachlorid is twice as toxic for cats as for dogs, but the safety factor for the therapeutic dose is about 27, whereas that for chenopodium as given above is about five. As a rule, carbon tetrachlorid can be given with safety to kittens three weeks old.

Hookworms. Carbon tetrachlorid as above.

Tapeworms. The same drugs that are used to remove tapeworms from dogs may be used to remove tapeworms from cats, the dose being diminished in accordance with the size of the animal.

TREATMENTS FOR FOX PARASITES

Ascarids. Carbon tetrachlorid in capsules at the rate of 0.3 cc. per kilo, as for hookworms in dogs. It is reported that the use of a small balling gun and a speculum is the most satisfactory mode of administering these capsules to foxes. Allen recommends chenopodium, 15 to 20 minims, in capsules, for adults; give adequate dose of castor oil with this. The efficacy of both drugs against ascarids in foxes is reported as approximately 100 per cent.

Hookworms. Carbon tetrachlorid as given above for ascarids. Efficacy, 93 per cent or higher.

Whipworms. The treatment recommended in the case of the dog whipworm would probably be effective, using suitable doses, but unless treatment was very necessary the difficulties of giving repeated doses of santonin to foxes would not warrant it.

Tapeworms. The treatments recommended in the case of dog tapeworms would probably be effective, using suitable doses.

Flukes. Carbon tetrachlorid, as given above for ascarids, is reported by Jeffreys as 100 per cent effective in removing intestinal flukes from foxes.

TREATMENTS FOR POULTRY PARASITES.

Large roundworms (Ascaridia perspicillum): A mass treatment recommended by Herms and Beach is as follows: For 100 birds, steep one pound of finely chopped tobacco stems for two hours in water enough to cover them. Mix the stems and the liquid with one-half the usual ration of ground feed. The day previous to treatment withhold all feed, giving water only. After fasting 24 hours, feed the mash thus prepared, and two hours after it is cleaned up give one-fourth of the usual amount of ground feed mixed with water in which Epsom salt has been dissolved at the rate of 11 ounces for each 100 birds. The treatment should be repeated 10 days later.

For a mass treatment where only a single treatment is given, use one teaspoonful (approximately one fluid dram or 3.75 cc.) of oil of chenopodium, thoroughly mixed with a moist mash, for each 12 birds.

For individual treatments, oil of chenopodium, 0.2 cc., in castor oil, 2 cc., has been found to remove 69 per cent of these worms; turpentine, 2 cc., in castor oil, 8 cc., has been found to remove 76 per cent of these worms.

Cecum worm (Heterakis papillosa): Rectal injections of oil of chenopodium, 0.1 cc., in a bland oil (as cottonseed oil), 5 cc., to birds

weighing 1.5 pounds (ca. 700 grams), given by means of a hard rubber rectal syringe, infant's size, has been found to remove 90 per cent of these worms. Double the dose for birds weighing three pounds or over. The tip of the syringe should be passed along the floor of the cloaca.

For a mass treatment, the tobacco treatment given above for the large roundworm has been found, when given once and not repeated, to remove about one-fifth of these cecum worms. If repeated at intervals of a month this might serve as a control measure of some value.

Spirurids. We have as yet no known effective treatment for the spirurid worms which occur more or less embedded in the tissues of the digestive tract of poultry.

Tapeworms. No satisfactory treatment has yet been established for tapeworms in poultry. A mass treatment which has been recommended is as follows: A gallon of a mixture of wheat and oats, to which is added a small tablespoonful of concentrated lye, is cooked slowly for about two hours and allowed to cool. The birds are fasted for 15 hours and then given as much of the mixture as they will eat, with plenty of water.

ADDENDUM

Lamson has recently reported good results in removing stomach worms from sheep by means of a nicotine sulphate solution. Using a commercial preparation containing 40 per cent of this substance, he makes solutions of three strengths, adding one, two or three teaspoonfuls to a quart of water. For weak sheep, use the weakest solution at the rate of 4 ounces to an adult and 2 ounces to a lamb. For average animals use the same doses of the stronger solution, and for strong animals the same does of the strongest solution. Fast for 12 hours before and 8 hours after treatment.