Internal Parasites of Horses and Mules

BY AUREL O. FOSTER

SOME 150 KINDS of internal parasites infest horses and mules, and probably no individual animal is ever entirely free of some of them. Fortunately, comparatively few do real damage—but those few can be extremely harmful and sometimes deadly. Here are the facts about a complicated subject.

THE DOMESTIC EQUINES provide shelter and subsistence to approximately 150 kinds of protozoa and worms which live, as internal parasites. There are few horse owners who have not had some first-hand experience with many of these, and nearly everyone is familiar, in one way or another, with at least some of them. Among the protozoa are the blood-inhabiting trypanosomes and piroplasmata, the ciliates of the large bowel, and several miscellaneous species. The parasitic worms include flukes, tapeworms, stomach worms, large roundworms, strongyles, pinworms, lungworms, filariae, and some others.

Some of the worst diseases of equines are caused by these invaders; yet they do not, as a rule, cause specific and spectacular diseases. In every case of harmful parasitism, the damaging effects are essentially of two kinds—general and specific. The general effect, although seldom as obvious, is unquestionably more important than the specific effect from an economic standpoint; it always causes a loss in the functional efficiency of the animal as a working unit. In some instances, as in such a disease as dourine, the specific effects, clinical or pathological or both, definitely indicate the disease. In most cases, however, as best typified, perhaps, by strongylosis, the

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2 Horse bots as internal parasites of horses and mules are discussed in another article in this volume.
specific effects are subordinated to the net general effect of the parasitism—decreased efficiency. Symptoms in such cases are manifold, but so variable as to preclude definite diagnosis.

The full importance of parasitism is inadequately understood. The parasite itself is ordinarily dealt with as the agent of disease or debility, but it is possible that parasites play some role in the transmission of other serious diseases, provide portals of entry for harmful micro-organisms, or serve as reservoirs of infection for other diseases. Moreover, parasites may be capable in themselves of exerting effects which have not hitherto been noted. Investigations along these lines have only begun.

Equines everywhere appear to be infected with internal parasites. There are, however, important differences in degree and kind of parasitism in different parts of the world and among individual horses and mules. Fortunately, several of the more pathogenic, or disease-producing, species, such as the blood-inhabiting protozoa, are limited in their distribution and incidence. The intestinal protozoa, however, occur everywhere and possibly in every horse and mule. The most numerous of these are the ciliated forms that live chiefly in the colon. They can be detected readily by microscopic examination of a watered drop of fresh manure. Some of the parasitic worms are distributed more or less regionally, but as there are so many kinds of them and they are so unrelated, it is difficult to make any general statement about them. Most of the important nematodes, too, particularly the strongyles, are found wherever there are equines, and it is doubtful whether any horse or mule is entirely free of them, except perhaps for a short period after an efficient anthelmintic has been administered.

Differences in distribution are probably determined, in general, by differences in developmental cycles. For example, the distribution of species which require intermediate hosts for transmission is more limited than that of species which are able to develop during a short period in the open. Also contributing to the distribution of equine parasites is the fact that horses and mules, perhaps more than other domestic animals, have been transported widely for service in war and in colonizing enterprises and for racing and breeding purposes.

Some of the parasites—most of the trypanosomes, for example—are capable of infecting a wide range of mammals, but the majority are so specialized that they can exist only in equine hosts. Some species, indeed, are better adapted to horses and mules than to donkeys, and others prefer donkeys to other equines. In general, horses and mules appear to be about equally susceptible to most parasites, although some kinds, such as the trypanosomes, are more injurious to horses than to mules.

Within their hosts these parasitic organisms exhibit a high degree of adaptability to specific locations. Most of them normally parasitize the alimentary tract, lungs, body cavity, or blood stream. In the alimentary tract, however, some species are exclusively parasites of the stomach, others of the small intestine, and others of the large intestine. Moreover, the several species of strongyles which inhabit
the large bowel tend to become localized in specific parts of this organ—the cecum, the ventral colon, or the dorsal colon. In addition to the parasites thus localized, several of the species follow various migratory circuits within the host, whereas many are aberrant, or wandering, in their habits. Consequently, scarcely a part or organ of an animal is entirely free from potential parasitic invasion. Thus there are parasites of horses and mules that live on the surface of the body; in the nose, ears, and eyes; in the skin, muscles, ligaments, visceral organs, or body cavity; or elsewhere in the body. It will also become evident from the following discussions that a parasite which in its adult stage normally inhabits one region of the body may, in its immature stages, be responsible for serious injury in an entirely different part.

PROTOZOAN PARASITES

Except for a few species, the protozoa of equines fall into two groups, those that inhabit the blood and those that live in the large bowel. All the important disease-producing agents are in the first group. The latter group embraces a large number of species that are essentially innocuous and may, in some instances, be actually beneficial to their hosts. In general the former require an intermediate host for their transmission or have an otherwise complicated life history, whereas the latter follow a simple, direct developmental cycle. Those of the blood-inhabiting group are chiefly trypanosomes and piroplasmata, which fortunately have a relatively limited distribution. Although herds have been decimated by infection with these organisms, the incidence of infection is usually not high, even in endemic areas, where cases of infection are always present. In contrast, the latter group—those inhabiting the large bowel—is composed principally of ciliates, which are believed to occur in all equines everywhere.

TRYPANOSOME DISEASES

The trypanosomes are by far the most important protozoan parasites of equines. They cause such diseases as dourine, surra, nagana, mal de caderas, and murrina, each of which takes a heavy toll among the equine populations of regions where it has become established.

Dourine is the only one of these trypanosome diseases that occurs in the United States. It is caused by Trypanosoma equiperdum and is widely distributed. It differs from other trypanosome infections in that it is essentially chronic rather than acute and is transmitted directly from horse to horse, usually during coitus, without the assistance of an insect or mammalian vector.

Surra, caused by Trypanosoma evansi, is the oldest recorded trypanosome disease of equines. It is an acute, usually fatal, infection, running its course generally within a few weeks. It occurs chiefly in central and southern Asia and in the Philippines. Horseflies (Tabanus...
species) are thought to be the chief vectors, although the method of spread is purely mechanical.

The disease nagana is prevalent in east and central Africa and does not occur elsewhere. The commonest agent of the infection is *Trypanosoma brucei*, a variety of which is the cause of Rhodesian sleeping sickness of man. In equines the disease is usually fatal in a few weeks, being too acute for the characteristic manifestations of sleeping sickness. It is carried from horse to horse by tsetse flies, in which the trypanosome completes a definite cycle of development.

Mal de caderas is related to surra and may be identical with it. It differs from typical surra, however, in the apparent morphology (form and structure) of its causative agent, *Trypanosoma equinum*, and in its distribution. It occurs only in South America and is believed to be transmitted by horseflies and stableflies.

Murrina, like mal de caderas, is similar to surra, and its causative agent, *Trypanosoma hippicum*, is closely related to *T. evansi*. The disease occurs chiefly in Panama, where it is transmitted, at least in part, by bloodsucking vampire bats. Affected animals, if untreated, usually die in a few weeks or months.

**PIROPLASMOsis**

Piroplasmosis, also known as tick fever, biliary fever, and hemoglobinuric fever, is an acute febrile condition characterized by jaundice, hemoglobinuria (hemoglobin in the urine), and anemia. It is caused by the presence of microscopic organisms, known as piroplasms of piroplasmata, in the red blood cells. In important respects it is like tick fever of cattle, but it does not occur in the United States. The majority of cases apparently recover, some within a few days or weeks, but the blood usually remains infective for several months or even years. Unlike the trypanosome infections, piroplasmosis confers a reasonably durable immunity. *Nuttallia equi*, the commonest agent of equine piroplasmosis, occurs in Africa, southern Europe, Transcaucasia, southern Asia, and South America. In Africa, it is transmitted by ticks belonging to the genus *Rhipicephalus*. Another species of the organism, *Babesia caballi*, occurs along with *Nuttallia equi* in Italy, India, and Macedonia, and is also found in Russia, Transcaucasia, North Africa, and Panama. This organism also is transmitted by ticks, chiefly species of *Dermacentor* and *Boophilus*.

**INTESTINAL CILIATES AND OTHER PROTOZOA**

At least 50 species of ciliated intestinal protozoa, belonging to half as many genera, are common inhabitants of the large bowel of equines. There is no acceptable evidence that they cause disease; indeed, various investigators have now and then advanced the hypothesis that these organisms perform some useful service for their hosts. They may, for example, assist the digestive functions by breaking down certain otherwise indigestible materials into sub-
stances that can be readily assimilated. Millions of these organisms pass out every day with the feces of an infected animal.

In spite of their universal presence in equines and their striking variety and abundance, the method of transmission of ciliated intestinal protozoa has not been satisfactorily explained. It is assumed that new hosts are infected by swallowing living organisms in contaminated food and drink, although it is recognized that such organisms, after entering by the mouth, would require certain adaptations in order to reach the cecum or colon.

Besides trypanosomes, piroplasmata, and ciliates, several miscellaneous species of protozoa occur in domestic equines, some more or less commonly. Among these are the muscle-infecting Sarcosporidida, plasmodial parasites of the blood similar to those causing human malaria, flagellates, and Suctoria of the intestine. Of interest are three species of amoebae that are analogous to three similar species occurring in man. They are Endamoeba gedoelsti (syn. E. intestinalis), the large and presumably harmless amoeba of the colon, comparable to E. coli of man; E. equi, a smaller colon amoeba; allegedly disease producing, suggesting the form parasitic in man, E. histolytica; and E. gingivalis var. equi, the equine variety of the human oral amoeba. About these very little is known, and only after further study can their importance be evaluated.

HELMINTHIC PARASITES

The helminths, or worm parasites, of equines are more varied and numerous than are the parasitic protozoa, and economically they are immeasurably more important. In contrast to the specific and fatal diseases caused by certain of the protozoa, the damage caused by worms is usually not spectacular; sometimes it is scarcely apparent, and rarely is it an immediate cause of death. Moreover, the symptoms are usually too general to serve for diagnosis. The important net effect of worm parasitism in equines is reduced efficiency. Judged on that basis, it becomes as obvious as it is paradoxical that parasites which kill their host animals are frequently of less economic significance than are those which insidiously undermine their efficiency.

HORSE STRONGYLES AND STRONGYLOSI

The horse strongyles are a large, unified group of approximately 40 species belonging to a single nematode family, the strongylidae. Most of them are relatively small, less than an inch in length; some are scarcely visible to the unaided eye. These are commonly known as small strongyles, cylicostomes, or Trichonema species. A few strongyles are large, as much as 2 inches long, and are usually firmly attached within the host and sucking blood. The front third of these larger worms frequently contains fresh blood, which gives that part a red color in contrast to the hind portion, which is darker and more or less slate-colored. There are three species of the genus Strongylus, which are variously referred to as large strongyles, sclerostomes, palisade worms, red worms, and blood worms. Undoubtedly the
widespread economic importance of these parasites largely accounts for the variety of common names applied to them.

All the strongyles have broadly, similar developmental cycles. During their adult life, they live in the large bowel and tend to become localized in one or another part of this relatively limited portion of the digestive tract. The females deposit large numbers of eggs, which leave the host’s body with the feces. The eggs can, and probably normally do, develop and hatch while in the bolus of feces. Unlike the eggs of many parasitic nematodes of other hosts, they do not appear to be delayed or inhibited in their development until the feces are diluted with rain water, earth, or some other agent. This adaptation probably protects the eggs and larvae from the damaging effects of such natural factors as sunlight, desiccation, and cold. Embryonic development is rapid, and the first-stage larvae usually hatch during the second day. In 6 to 10 days, the larvae molt twice and become third-stage, infective larvae. The second sheath is retained, probably as further protection against the hazards of an unfavorable environment. First- and second-stage larvae die rapidly when subjected to drying, marked heat or cold, or excessive bacterial action, but the infective larvae may survive for months or even years under these conditions. The infective larvae rest on the upper, more accessible portions of grass blades and are usually swallowed by horses during grazing. Once swallowed, they undergo a developmental cycle within the host many aspects of which are not yet perfectly understood.

Present evidence indicates that the large and small strongyles have certain essential differences in their cycles of migration and development within the host. The large strongyles migrate extensively within the host, and their migrations are associated with some of the most serious aspects of strongylosis. Moreover, it is becoming increasingly evident that the wanderings of the larvae of the three large strongyles take them to different localities in the host's body—Strongylus equinus to the pancreas, S. edentatus to the lining membranes and visceral supporting tissue of the body cavity, and S. vulgaris to the walls of the visceral arteries.

The small strongyles are believed to pass directly to the large intestine, where at least some of them penetrate the mucous membrane and settle down in the intestinal wall for a period of growth. It is doubtful whether all the cylicostomes undergo this tissue stage, since at autopsy fourth- and fifth-stage worms can usually be found both in the cavity of the intestine and encysted in the mucosa.

The palisade worms and their close relatives differ from the cylicostomes also in their mode of life within the large intestine. Most of the palisade worms attach themselves tenaciously to the mucosa and live as bloodsuckers; the cylicostomes, although capable of attachment, are usually found free in the lumen, but on the surface of the fecal mass in close contact with the intestinal lining.

It becomes apparent from what has been said that strongylosis is not a simple condition of parasitism. The bloodsucking activities of the adult large strongyles produce anemia, which in turn gives rise to many of the symptoms that ordinarily accompany severe
strongylosis. By shifting their points of attachment, these parasites leave minute hemorrhages and denuded areas which are favorable sites for bacterial colonization. In their larval stages, they cause transient inflammatory and irritative changes throughout the visceræ. Many of these ultimately become scars, adhesions, or caseous (cheese-like) nodules. The larvae of *Strongylus vulgaris* cause dilation and obstruction of blood vessels. Colic is a frequent result of the decreased blood supply to the intestine, and verminous inflammation of the inner wall of an artery always impairs the capacity for arduous work. Intermittent lameness is believed to result often from stoppage of the smaller leg arteries occasioned by the liberation of clotted particles from within a tumor of a blood vessel. Sometimes the wall of the vessel ruptures, causing sudden death by internal hemorrhage.

Animals with severe strongylosis exhibit lack of appetite, anemia, and progressive emaciation. The body wall has a tucked-in appearance, and the animal loses condition generally.

The diagnosis of strongylosis is not easy. The presence of the characteristic ova in the feces is evidence of strongyloid infestation, but not necessarily an indication of disease. Most horses in reasonably good condition pass a few of these ova. In general, however, a high concentration of strongyle eggs in the feces, combined with loss of condition and an absence of organic or infectious disease, is strong presumptive evidence of strongylosis.

Not all the 40 different kinds of strongyles have ever been found in any one horse or mule, but every animal almost invariably harbors several of them. It is, therefore, legitimate to ask how many kinds of strongyles occur in the average horse and what are the more or less average maximum and minimum numbers. Study of a considerable body of literature indicates that, qualitatively, strongyle infections of equines vary only slightly in different parts of the world and that, quantitatively, the average horse or mule harbors from one-fourth to one-half of the known strongylid species. One or more of the three species of large strongyles are usually present, along with 10 to 12 species of small strongyles. It appears that about 15 species account for the bulk of strongylid parasitism in equines and that the other 25 do not occur in significant numbers.

The characteristic strongyles occurring in the cecum of horses and mules may be said to be *Strongylus vulgaris*, *S. equinus*, *Cyathostomum coronatum*, *Cyclostephanus calicatus*, and *Cyclocoelum nassatus*. The majority of the strongylid fauna in the ventral colon are of the following species: *Cyclocoelum nassatus*, *Cyclostephanus minutus*, *C. calicatus*, *Cyclocoercus catinatus*, *C. pateratus*, *Cyathostomum labiatum*, *C. labratum*, *Triodontophorus minor*, and *Strongylus edentatus*. The typical fauna of the dorsal colon are *Cyclostephanus longibursatus*, *Cyclocoelum insignie*, *C. nassatus*, *Cyclocoercus goldi*, and *C. catinatus*.

Of the 36,000 strongyles recovered in one study, it was found that approximately four-fifths were accounted for by fewer than one-fifth of the species, the six commonest—*Cyclocoelum nassatus*, *C. insignie*,
Gylycosphatum longibursatus, C. calicatus, C. minutus, and Strongylus vulgaris—which are of the greatest economic importance.

Data from several studies suggest that equines harboring approximately 1,000 strongyles are lightly infected; that infections of 30,000 to 50,000 are not infrequent and probably do not as a rule produce symptoms; but that infections of over 50,000 are relatively severe and may result in more or less typical strongylosis.

Both the degree and, to a less extent, the kind of parasitism are affected by many factors, some of which it is possible to evaluate to a limited extent. For example, the size of worm infestations depends principally upon the extent of exposure to infection, and this is influenced by conditions of sanitation, feeding, medication, season, and climate. In addition, observational evidence has demonstrated that infections are more severe in younger animals. There are also certain apparent host “preferences” among the strongylids: Cyathostomum tetracanthum, Cylycoecylus muriculatus, and C. elongatus are characteristically found in donkeys and are relatively rare in horses and mules. Cylycocercus alveatus and Cylycocylus triaramosus are common only in zebras, but are more often found in donkeys than in horses or mules. Cylycosthephanus poculatus, typically found in horses, has been recorded once from a mule but never from donkeys or zebras. There is evidence also that some breeds of horses are probably more resistant to intestinal parasites than are others.

OTHER HELMINTHS AND THE DISEASES CAUSED BY THEM

Besides the strongyles, several more or less unrelated helminths, some of which are of considerable economic importance, affect equines. They are the flukes, tapeworms, stomach worms, ascarids, Strongyloides, pinworms, lungworms, and filariae.

Flukes

About a dozen species of trematodes, or flukes, have been reported, though not frequently, from the liver, blood vessels, and alimentary tract of horses and mules. Probably none are normal parasites of these animals. Those most commonly found in equines are the well-known liver flukes of sheep and cattle (Fasciola hepatica and F. gigantica) and certain species of blood flukes, of which Schistosoma indicum is the most important. The last occurs in India and Rhodesia but not elsewhere so far as is known.

Tapeworms

About 10 species of cestodes, or tapeworms, have been found in equines, but only 3 are of economic importance. These are Anoplocephala magna, A. perfoliata, and Paranoplocephala mamillana. The first is the largest of the horse tapeworms, although it seldom exceeds 10 inches in length. Its prominent head bears four conspicuous suckers, and the body is wide and tough. Anoplocephala
magna, which occurs normally in the small intestine and rarely in the stomach or cecum, is the commonest tapeworm of American horses. Heavy infestations cause intestinal catarrh, with a consequent disturbance of digestive functions sometimes leading to emaciation and anemia.

The so-called lappetted tapeworm (*Anoplocephala perfoliata*) is 1 to 2 inches long and usually lives in the cecum, although it is sometimes encountered in the lower end of the small intestine. It is responsible for characteristic changes in the mucous membrane. The parasites tend to become localized in a small area immediately surrounding the opening of the small intestine into the cecum, the so-called ileocecal valve region. A hundred or more specimens may be encountered within an area with a diameter of 3 or 4 inches, their heads tenaciously attached and their bodies tightly packed against one another. At this site, the mucous membrane undergoes marked irritative and inflammatory changes, the most serious and conspicuous being a rapidly growing granular lesion. This mass of growing tissue with its eroded surface is seldom larger than a tennis ball, but because of its location it progressively obstructs the ileocecal orifice. Sometimes, however, the process is one of making the tissue thinner rather than thicker, and this has led in some instances to perforation of the intestinal wall. Both processes result eventually in the death of the host animal. Although *A. perfoliata* is a widespread parasite of horses, its geographical occurrence is not well known. It appears to be relatively uncommon in continental United States, but it is the most frequently occurring horse tapeworm in some tropical countries, such as Panama and the Philippine Islands.

*Paranoplocephala mamillana* is known as the dwarf horse tapeworm. It seldom measures more than an inch in length and is relatively delicate. Although of widespread occurrence this tapeworm is seldom found in large numbers. It lives normally in the upper part of the small intestine and is of less economic significance than the two species already discussed.

The developmental cycles of the horse tapeworms have not been completely determined. The segments filled with eggs break off into the fecal mass, and the eggs are liberated either before or after the feces are deposited on the open ground. Judging from the recently determined cycles of a few related species of tapeworms, it appears probable that the eggs are ingested by arthropod intermediate hosts, perhaps certain pasture mites, in which the larval stages develop. This vector, in turn, is eaten by a grazing horse or mule.

**Stomach Worms**

Of some 9 or 10 kinds of parasitic worms that have been found in the stomachs of horses, 4 are normally parasitic in these hosts and are the causative agents of a complex of lesions which gives rise to a serious condition known as verminous gastritis or inflammation of the stomach. Three of these worms are closely related and are known as *Habronema muscae*, *H. majus* (syn. *H. microstoma*), and *H. magna*, which occurs normally in the small intestine and rarely in the stomach or cecum, is the commonest tapeworm of American horses. Heavy infestations cause intestinal catarrh, with a consequent disturbance of digestive functions sometimes leading to emaciation and anemia.

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Draschia (formerly Habronema) megastoma. They are transmitted by houseflies and small stableflies. The fourth species, Trichostrongylus axei, is more frequently a parasite of cattle, sheep, and goats than of equines and is so small that it may be overlooked at post mortem inspection unless a special search is made for it. T. axei does not require an intermediate host but infects the definitive host directly, after the manner of the strongyles.

Habronema muscae and H. majus are frequently seen on post mortem examination as slender, whitish worms actively whipping about in the stomach contents, especially if the contents are fluid or have been flushed out with water. The majority of specimens, however, live close to the glands of the stomach, embedded in mucus, or sometimes superficially embedded in the lining of the stomach. In this location it is sometimes difficult to discover them unless they are scraped or teased out. Horses harboring 200 or 300 worms generally have some inflammation of the lining of the stomach, and this contributes to gastric irritability, disordered digestion, and sometimes colic.

Draschia megastoma is less frequently found, but has more serious effects than the other species. These worms bury themselves deep in the mucous membrane and the layer beneath it and produce abscesses. Although such lesions are usually called tumors, they have, probably in every instance, a pus-filled or cheese-like core, in which are many worms and a cavernous tract communicating with the stomach. The tissue surrounding the central core shows marked thickening that gives the lesion a tumorous aspect. The diameter of the lesions varies from that of a walnut to that of an orange. Although these so-called tumors may occur in all areas of the glandular lining of the stomach, a preferred site is that portion nearest the border of the upper, nonglandular area. Not infrequently only a single abscess is present, although often there are many of various sizes. Because of their erosive nature, the abscesses produced by D. megastoma occasionally cause acute conditions, such as hemorrhage and perforation, but usually the injury is confined to irritative changes and more or less functional damage to the glandular mucous membrane.

The larvae of the larger stomach worms, especially those of the last-mentioned species, are responsible in part for a relatively common skin disease of horses called summer sores or bursati. Recently this condition has been increasingly referred to as cutaneous habronemiasis. Although the cause and development of this disease are imperfectly understood, available evidence indicates that the larvae are liberated when infected flies feed on skin wounds or sores. The immature worms in the head region of the fly probably escape by way of the fly's mouth when activated by the warmth of the horse's body. These larvae not only irritate the wounds and make them ugly in appearance but seem to prevent them from healing.

Trichostrongylus axei, the small stomach worm, is probably acquired by horses through association with ruminants. It is, however, a sufficiently important parasite of equines to have been considered by many investigators the principal cause of verminous inflammation.
of the stomach. Its mode of development is roughly similar to that of the strongyles, except that it does not wander in the body of the host and that it produces characteristic changes in the lining of the stomach. The worms are too small to be readily seen, but the infection can frequently be diagnosed on post mortem inspection by the character of the lesions. Not always, however, is infection with this species accompanied by grossly apparent lesions, and when such lesions are encountered, they may be of a varying nature. In general, stomachs infected with *T. axei* show a number of isolated, raised, buttonlike areas on the glandular mucosa. These may be the size of a dollar and depressed in the center, or they may be very small and inconspicuous. Sometimes the affected area is large and has a plateau-like appearance. In other cases the lesions are narrow at the base and somewhat mushroomed superficially. In all instances the disease process appears to be a progressive growth of tissue in response to irritative action by the worms.

Workers in both Europe and the United States have expressed the view that probably no other affection of equines is so regularly associated with a relatively sudden loss of condition.

The Large Roundworms, or Ascarids

The common roundworm, *Parascaris equorum*, is the largest parasite of equines. Female specimens vary from 6 to 15 inches in length; males, from 5 to 11 inches. When fully grown they have about the diameter of a lead pencil. They live in the small intestine and are typically parasitic in foals and young animals; only rarely are ascarids important in horses over 4 and 5 years of age, although a few specimens may be present in older animals.

The development cycle of the horse ascarid is simple except for a rather complicated migratory circuit within the host. Female worms in the small intestine deposit many eggs, which pass to the outside with the feces. If the weather is warm and the environment not excessively dry, the eggs develop embryos and are infective to horses in about 2 weeks. When the infective eggs are swallowed by grazing horses, the embryos are liberated in the intestine. They rapidly penetrate the gut wall and are taken by the blood stream to the liver and thence through the heart to the lungs. In the lungs, usually about a week after infection, the larvae escape from the blood stream and migrate up the trachea to the pharynx. After being swallowed once more, the worms develop to maturity in the small intestine.

Because ascarids do not attach themselves to the intestinal mucous membranes they are sometimes considered to be relatively innocuous. In reality, however, they have three attributes which make them very dangerous: (1) The migrations of the larvae through the liver and lungs cause extensive injury to these organs. In massive infections, serious inflammation of the liver or lungs may result. (2) The large size of the adult worms makes heavy infections particularly injurious. In foals the presence of large numbers of ascarids is a fairly frequent cause of partial obstruction of the small intestine, and fatalities from
complete obstruction or perforation have been recorded. (3) The large roundworms tend to wander about in the intestine and, if the environment becomes unfavorable, to seek escape through whatever channels are accessible. Cases are recorded of invasion and obstruction of the common bile duct and, more frequently, of the escape of worms into the stomach and even out of the body by way of the mouth or anus.

**Strongyloides**

Very small, slender worms, *Strongyloides westeri*, occur in the small intestine of nursing foals and are believed to be responsible, at least in part, for the high incidence of scouring among these young animals. Mature horses and mules seldom harbor this species.

The parasitic adults live in intimate contact with the lining of the gut and reproduce asexually. Eggs are liberated into the lumen and have already developed embryos when they pass out with the feces. These are usually the first parasite eggs to appear in the feces of young foals. The larvae hatch in a day or so and are capable of undergoing alternative cycles of development, either transforming directly into infective larvae or growing into free-living, bisexual adults. The latter mate in the manure or on the ground, and the females lay eggs which, in turn, develop into larvae that are infective to equines. The entire cycle is completed within a few days. It is not known whether horses acquire infection by direct skin penetration by the larvae, although this is probable, or by ingesting the larvae during grazing or in contaminated water. At post mortem inspection, the presence of *Strongyloides* may be suspected if the mucous membrane of the upper part of the small intestine exhibits localized inflammation and reddening. The worms can be removed by scraping, and a diagnosis can be made with a low-power microscope.

**Pinworms**

Whitish worms with long slender tails, pinworms (*Oxyuris equi*) are frequently seen in the feces of heavily infected animals. This fact at once suggests a useful method of diagnosing pinworm infection and an important point in the developmental cycle of this parasite. The worms mature in the large intestine, principally in the dorsal colon, the females becoming full of eggs as they proceed along the small colon toward the rectum. Sometimes the females crawl out of the anal opening and then rupture, leaving the eggs glued to the peri-anal region. The resultant irritation and itching cause the affected animal to rub itself against posts or other objects, and this frequently leads to secondary infection, which accentuates the discomfort. Rubbing may also crush more female worms on the perianal surfaces. Normally, however, the eggs develop on the ground or in manure, and infection is acquired as in the case of the large roundworms.

Male pinworms are much smaller than the females and appear to live principally in the dorsal colon. In this region also are found at post mortem examination many fourth-stage larvae, which are peculiarly equipped with large muscular mouths for attachment to the mucosa and for voracious feeding.
In addition to the perianal injury produced by pinworms, there is the possibility that the eggs or the matrix of the uterine substance in which they are embedded may have some peculiarly irritating property. The fourth-stage larvae are also injurious on account of their mode of life within the colon. Diagnosis can be made by finding the characteristic eggs in perianal scrapings or by the discovery of adult worms in the manure. Tail rubbing is presumptive evidence of infection.

Pinworms of another species, Probstmayria vivipara, are frequently present in large numbers in equines, but they are so small as to be scarcely visible to the unaided eye. These are viviparous worms, as their species name implies—that is, the young are born alive, the eggs being hatched within the body of the female—and they can presumably complete their entire cycle of development in the ventral colon of the host. Nothing is known of the injuriousness of this species or of its means of transmission from horse to horse.

Lungworms

Lungworms of the species Dictyocaulus arnfieldi, which live in the bronchi and bronchioles of horses, are of scattered occurrence in the United States and elsewhere. In heavy infections they cause a chronic cough and bronchitis, which weaken the host animal.

The females produce eggs with embryos which hatch in the lungs soon after deposition. The embryos are coughed up through the trachea or are carried up by the action of its ciliated lining. Then, in general, they are swallowed and pass out through the alimentary tract, though in some cases they are expelled from the body during coughing or sneezing. The larvae become infective within a week or so and produce infections in new hosts that swallow them. Larvae reach the lungs after a migration somewhat similar to that of the large roundworms and grow to maturity there.

Filariae

Of the several species of filariae which have been described as being found in equines, many are known only by their larval stages (microfilariae) and it is probable that some, at least, are identical. Only two are of common occurrence.

One of these, Setaria equina, is the well-known threadworm of the abdominal cavity. It lives normally in intimate association with the supporting tissues of the intestine, but it is sufficiently large (about 4 inches long) and active to be easily detected at post mortem examination. So far as is known, this parasite does not usually produce serious injury. Infections consisting of a dozen or more threadworms are, however, capable of causing inflammation of the lining of the body cavity and effusion of fluid into this region: 10 liters (about 21/2 gallons) or more of free fluid may be present in the abdominal cavity as a result. Occasionally, also, the immature forms of this filaria get into the eyes and cause severe disturbance and serious local injury.

The other filarial worm, Onchocerca reticulata, parasitizes the
ligamentum nuchae (the large tendon supporting the neck) and is believed to have an important role in the development of poll evil and fistulous withers. Not infrequently, infection with this species leaves only chalklike, elongate nodules or bundles buried in the ligamentous tissue. Recent studies suggest that the microfilariae of this parasite are responsible for skin lesions in horses and probably for the condition referred to as dhobie itch.

Both of the species named have indirect life cycles, horses probably acquiring infection from the bites of infected insect hosts. Although the vectors of *Setaria equina* have not been definitely determined, it has been shown by recent studies that *Onchocerca reticulata* is transmitted by tiny biting flies known as midges.

**TREATMENT FOR PROTOZOAN DISEASES**

Two kinds of agents are used with some success in the treatment of the trypanosome diseases of equines—antimony compounds and synthetic metal-free organic chemicals. The antimony compound first used successfully is tartar emetic (antimony potassium tartrate). Though very effective, this is also very toxic. It is administered by injection into the veins and care must be taken that no trace of the drug gets into the tissues. With colts and shy animals that jump at the prick of the needle, it is difficult to prevent the escape of the drug into surrounding tissue. This will cause swelling and abscess formation and, in the more severe cases, a sloughing of tissue about the site of injection. Principally to avoid these objectionable effects, many other antimony compounds have been tested against the equine trypanosomes. From the evidence available it is impossible to select the most valuable of these substances but a proprietary drug manufactured and sold under the name “Fuadin,”<sup>4</sup> may be taken as an example of the advantages and disadvantages that have accrued from this type of investigation. This compound may be given by either intravenous or intramuscular injection, and it is less acutely toxic than tartar emetic. Apparently, however, animals treated with this drug are more likely to relapse than are those treated with tartar emetic. Also Fuadin is the more expensive of the two and is considered uneconomical for use in some localities.

Several arsenicals have also been tested. Arsenic is a metal very similar chemically to antimony. Although some investigators have reported successful results with one or another of the arsenic compounds, the reports suggest that in general they are less effective than are the antimony compounds.

The only synthetic, metal-free, organic compound that has been used extensively and successfully in equine trypanosomiasis is a complex urea derivative.<sup>5</sup> The drug is dissolved in water and injected either intravenously or intramuscularly. Usually the treatment is repeated after a fortnight. The trypanosomes in the peripheral (exterior) circulation are quickly destroyed, and sometimes a complete

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<sup>4</sup> A 6.7 percent solution of sodium-antimony III bis-pyrocatechin disulfonate of sodium, having a pH of 7, and containing 13.5 percent of trivalent antimony.

<sup>5</sup> This is marketed under many names but is best known as Bayer 205, Germanin, and Naganol.
cure is obtained. Many relapses, however, have followed this treat-
ment, though some of these, and possibly all, may have been caused
by organisms that had invaded the spinal fluid prior to treatment
or by failure to administer a curative dose of the drug. Some in-
vestigators have injected this as well as other drugs directly into the
neural canal (in the backbone), which is often a reservoir of infection.
Some successes have been reported with this technique, but the method
is not practicable on a large scale. In brief, then, this drug may be
employed most effectively in early infections but is of limited value
in the more advanced cases.

After extensive experience with murrina in Panama, investigators
there resorted to a combination of the drug mentioned above with
one of the metallic compounds. The intravenous injection of a solu-
tion containing 1.3 grams (21 grains) of tartar emetic and 0.5 gram
(8 grains) of Bayer 205 has given good results in many cases, but
the frequency of relapses makes it impossible to recommend this
as a wholly satisfactory method of treatment.

Because of its powerful action in killing trypanosomes, Bayer 205
has been used as a disease preventive with some success. Injections
of the drug at triweekly intervals have been found to provide satis-
factory protection against infection, but the expense of this procedure
is often prohibitive. Moreover, many animals react unfavorably to
repeated administrations of this drug.

Many remedies have been tried for piroplasmosis. The most satis-
factory seems to be a compound known as acaprin or akiron. It is
given either subcutaneously (under the skin) or intramuscularly, and
in many cases a single injection is sufficient. In some animals it has
cаused undesirable side reactions, which, however, are reported to
have been avoided to a large extent when the drug was administered
in conjunction with a substance known as rephrin. Formerly a
proprietary remedy (akiron R) was manufactured that contained
rephrin as well as acaprin.

TREATMENT FOR PARASITIC WORMS

For stomach worms (Habronema species, and others) and large
roundworms (Parascaris equorum), carbon disulfide is the most com-
monly used anthelmintic. The chemical is given to animals after
they have fasted 18 hours and is administered in doses of about 6 fluid
drams. Ordinarily the drug should be given by stomach tube, but a
skillful veterinarian may be able to administer it satisfactorily in
capsules. Carbon disulfide is irritating to the membranes of the
mouth, and for this reason it must be carefully administered to avoid
contact with them. It also causes marked inflammation of the mem-
branes of the stomach and occasionally produces other unfavorable
reactions. The latter are sometimes counteracted by a purgative dose
of magnesium sulfate, administered some time after the anthelmintic.

The large numbers and wide distribution of strongyles have given
rise to the use and development of many anthelmintics for their

^Chemically, N, N'-(Bismethyl-chinolylium-methylsulfate-6-).
removal. Most of these remove only part of the worms, whereas others which are effective cause more or less severe intoxication, or poisoning. The traditional drug used against these parasites is oil of chenopodium. It is very effective and quite safe, but animals are usually slow to recover from the after effects. Carbon tetrachloride is also effective but has proved toxic under certain conditions. Normal butylidene chloride, although effective, has never been widely used because of its high cost. A closely related chemical, normal butyl chloride, which seems to be equally effective, is less expensive but is unfortunately metabolized in the horse to a very unpleasant smelling substance. All these drugs must be given after an extended fast and must be followed by a purgative.

Workers in the Federal Bureau of Animal Industry have recently introduced a new anthelmintic, phenothiazine, which seems to lack most of the objectionable features of the drugs previously used. It should be given without a preliminary fast and need not be followed by a purgative. This new drug is highly effective for the removal of strongyles, and it is usually nontoxic in therapeutic doses, although a temporary anemia and some jaundice frequently follow its administration. An occasional death is reported to have been caused by phenothiazine, although thousands of horses have been successfully treated. Its contraindications (conditions under which the drug cannot be used safely) and incompatibilities are incompletely determined, but present evidence indicates that the advantages of phenothiazine may far outweigh any disadvantages that might accompany its use. The therapeutic dose is 30 to 50 grams (1 to 1¾ ounces) for an adult equine. It may be administered by capsule, by stomach tube, or by mixing the drug with suitable feedstuffs. It is important that doses be prepared separately for each animal and that animals be dosed individually. Phenothiazine may be made into a satisfactory suspension for use as a drench by mixing one dose of the drug with 20 cubic centimeters (two-thirds ounce) of molasses and adding enough water to make 90 cubic centimeters (3 fluid ounces). In order to obtain a smooth mixture, the water must be added in small quantities and stirred into the molasses-phenothiazine mixture after each addition of the fluid. When medicated feed mixtures are used, the drug may be mixed with almost any suitable ground feed or mixed grain. It is simplest merely to moisten the feed (2 to 2½ quarts of feed to one dose) and mix in the drug. If this medicated mixture is fed in lieu of a regular afternoon feeding, horses will usually consume it during the night.

CONTROL MEASURES

Since most equine parasites owe their perpetuation to the fact that the animals graze or take their feed from the same places that they deposit their feces, a good deal can be accomplished toward reducing parasitism and keeping animals in good condition by providing sanitary stables and good pastures and by avoiding overstocking. Manure should be removed frequently from stables, which should be of good construction and kept clean. Before spreading the manure out
as fertilizer, it is important, if practicable, to destroy the parasite eggs and larvae contained in it. Eggs and larvae are killed by spontaneously generated heat if the manure is stored in a specially constructed, insulated box for 2 or 3 weeks before being used. Grain boxes and hay racks should be so placed as to avoid contamination with manure. Attention to these details and periodic medication for worms are the best general measures for keeping horses free from parasites.