

Helminths and helminthoses of the dromedary. A review of the literature

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Summary: This review deals with helminth parasites of the digestive tract, liver, respiratory system, circulatory system, nervous system, eye, muscle tissue and subcutaneous tissue of Camelus dromedarius. A table lists the anthelmintics which can be used in this species, and shows that available medication is highly effective against all parasites except Trichuris spp. and Strongyloides spp.

KEYWORDS: Camels - Cestoda - Dromedary - Helminthoses - Nematoda - Parasitology - Reviews - Trematoda.

INTRODUCTION

Although it would not seem that the environment in which camels live is conducive to the development and transmission of helminths, the helminth fauna of these animals is, in fact, one of the richest, for this review cites 77 species.

Although Leese wrote in 1917 that the helminths of camels were of no importance to the veterinarian, since then there have been numerous publications on this subject, which draw attention to its growing importance. This coincides with a rekindling of interest in camel breeding in recent years, particularly in Africa.

In another review of the literature on the helminth parasites of camels, El Bihari (71) gave a list of species encountered frequently and their pathogenic effects, together with a list of those encountered occasionally. We are aware of 30 species not mentioned by this author, who provided no information on the geographical distribution of species. It is our purpose here to present a more complete list of parasitic species together with their broad geographical distribution, pathogenic effects and the principal control measures which can be recommended.

HELMINTHS AND HELMINTHOSES OF THE DIGESTIVE TRACT

HELMINTHS PARASITIC IN THE DIGESTIVE TRACT

The helminth fauna of the digestive tract of Camelidae is particularly rich, amounting to almost 50 species.

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In the rumen:

Various species of *Paramphistomum* which also occur in ruminants have been found in camels, particularly *Paramphistomum cervi* (Zinder 1790) (71). Lodha *et al.* (123) also recorded the presence of hydatid cysts of *Echinococcus granulosus* (Batsch 1786).

In the abomasum:

Haemonchus longistipes (Railliet and Henry 1909) is specific to camels and is found in:

- Africa: East (116, 146, 193, 194, 127, 170, 34, 161, 13, 167)
North (according to 191)
West (133)
Centre (88, 89, 91, 92, 60, 61, 161, 163, 201, 196).
- Asia: Arab Peninsula (8, 72, 100, 71)
India and Pakistan (84, 39, 115, 29, 30, 32, 157, 142)
USSR (180, 94, 27, 118, 191).

Haemonchus contortus (Rudolphi 1803): this nematode is frequently found in camels which have shared grazing with sheep. It has been found in Africa (116, 88, 82, 161, 203, 204, 166, 167) and Asia (71).

Camelostrongylus mentulatus (Railliet and Henry 1909): according to Levine (118), Dunn (69), Soulsby (191) and El Bihari (71), the geographical distribution of this nematode coincides with that of camels. However, in the African continent it is common only in the North (58), and is quite rare elsewhere.

Ostertagia circumcincta (Stadelman 1894) and *O. trifurcata* (Ramson 1907) are cosmopolitan parasites, but they are best adapted to sheep. However, they are also found in camels (118, 98, 71).

Marshallagia marshalli (Ransom 1907) is very common in sheep in the mediterranean area, but has been reported from camels only in India and the USSR (118, 69, 191, 71).

M. mongolica (Shumakovich 1938) seems to have a very limited geographical distribution, having been found (among camels and sheep) only in Mongolia (63, 118, 69, 191).

Physocephalus sexalatus (Molin 1860) is essentially a parasite of pigs, but it has been found in camels (138, 118, 134, 69, 191).

Parabronema skrjabini (Rasovska 1924) is a spirurid nematode frequently identified in Asia (139, 118, 69, 72, 100, 71). In dromedaries it has been reported in Africa (118) including Ethiopia (161).

In the small intestine:**(a) Nematodes**

Among species of the genus *Trichostrongylus*, *T. colubriformis* (Giles 1982), *T. probolurus* (Railliet 1896) and *T. vitrinus* are the species found most often in camels, having been identified in:

- Africa (156, 51, 147, 193, 194, 127, 89, 91, 92, 185, 34, 161, 163, 166, 167, 196)
- Asia (15, 27, 179, 11, 142, 8, 47, 72, 198, 5)
- America (107).

T. colubriformis essentially parasitizes the duodenum, but has been found occasionally in the abomasum. The other two species are found in the small intestine.

T. calcaratus (Ransom 1911) and *T. affinis* (Graybill 1924) are mainly parasites of rodents which have been found occasionally in Camelidae (136, 118, 191, 71).

Cooperia oncophora (Railliet 1898) and *C. pectinata* (Ransom 1907) occur mainly in the small intestine and exceptionally in the abomasum of ruminants. They have an extensive geographical distribution and are found occasionally in camels (118, 69, 191, 98, 100, 41, 71).

Nematodirus spathiger (Railliet 1896), *N. mauritanicus* (Maupas and Seurat 1912), *N. abnormalis* (May 1920), *N. dromedarii* (May 1920) and *N. helveticus* (May 1920) have been identified in the small intestine of camels wherever they are kept (199):

- Africa: East (127, 170, 172, 110)
West (133)
North (129, 58)
Centre (88, 89, 91, 92, 82, 158, 161, 162).
- Asia: USSR (5, 19, 26, 164, 186, 178, 179)
Pakistan and India (39, 115, 32, 29, 142)
- Europe: Railliet (159) and Enigk (74).

Nematodirella dromedarii (May 1920) is exclusive to the dromedary (67, 118, 120, 121).

N. cameli (Rajewskaya and Badinin 1933) has been found in camels in the USSR (5, 118).

Impalaia tuberculata (Monnig 1923) and *I. nudicollis* (Monnig 1931) have both been identified in dromedaries occasionally throughout Africa (138, 136, 137, 188, 89, 91, 92, 34, 161, 163, 196).

I. aegyptiaca (Soliman 1956) has been found only in Egypt (188), and *I. taurotragi* (Le Roux 1936) only in South Africa (Le Roux 1936). Reviewing the genus *Impalaia*, Gibbons *et al.* (86) concluded that the last-named species was morphologically identical with *I. tuberculata*, and consequently confused with it.

Strongyloides papillosus (Wedl 1856) has been found frequently among dromedaries in Africa (193, 194, 70, 89, 91, 92, 34, 161, 163, 196, 204). It has been identified in Europe in zoo animals (74, 44).

Bunostomum trionocephalum (Rudolphi 1808) is essentially a parasite of small ruminants, but it has been found in dromedaries in Africa (34, 161) and Asia (71).

(b) Cestodes

Seven species, all belonging to the family *Anoplocephalidae*, have been identified in the small intestine of camels.

Moniezia expansa (Rudolphi 1810) is a cosmopolitan parasite which has been found in camels in:

- Africa (136, 137, 70, 127, 133, 66, 89, 92, 34, 163, 196, 204)
- Asia (112, 115, 192, 103, 181, 100, 71).

M. benendeni (Moniez 1879) is less common than *expansa* and its geographical distribution is more restricted, having been identified only in Africa (132, 66, 89, 91, 92, 34).

Stilesia globipunctata (Rivolta 1874) is widespread in Africa (89, 91, 92, 34, 163) and has been found also in India and Pakistan (114, 192, 32), USSR (181) and Europe (74).

Stilesia vittata (Railliet 1896) has been found only occasionally in Africa (102, 61, 163) and Asia (181).

Stilesia centripunctata (Rivolta 1874) is widespread in Africa (89, 92, 61, 34, 163) and Asia (114, 192, 32, 181).

Avitellina woodlandi (Bhalerao 1936) has been identified in Africa (136, 137, 127, 89, 91, 196).

Thysaniezia ovilla (Rivolta 1878) has been found in dromedaries in Chad (89, 92).

In the large intestine:

In the large intestine, 11 species of nematodes have been identified:

Oesophagostomum columbianum (Curtice 1890) is essentially a parasite of small ruminants, but it has been found in dromedaries in Africa (89, 91, 92, 161, 163, 203, 166, 196, 58).

Oesophagostomum venulosum (Rudolphi 1809) is another parasite which occurs mainly in small ruminants, and has been found occasionally among camels in Africa (127), Asia (15) and Europe (159, 44).

Oesophagostomum vigintimembrum (Canavan 1931) seems to be specific for the dromedary, in which it has been found only occasionally (155, 92).

Chabertia ovina (Fabricius 1794) is a parasite of ruminants, particularly sheep, encountered rarely in camels (118, 71, 58).

Trichuris globulosa (Von Listow 1901) is one of the commonest and most widespread trichurids of camels, reported from:

- Africa: East (127, 104)
North (58)
Centre (82, 89, 91, 92, 34, 161, 163, 167)
- Asia (32, 157, 47, 100, 71)
- Europe (28, 85)
- USA (107, 27).

T. cameli (Rudolphi 1819) is specific for camels, occurring in India according to Neveu-Lemaire (138), Skrjabin *et al.* (183) and Levine (118).

T. ovis (Abildgaard 1795) is a cosmopolitan parasite of sheep, occasionally encountered in other species, including camels (138, 183, 118, 161).

T. skrjabini (Baskalov 1924) occurs in the USSR among dromedaries and other ruminants (138, 183, 118).

T. affinis (Rudolphi 1802) may be identical to *T. ovis* according to some authors (138, 183, 82, 118). Dunn (69) regarded it as a distinct species which infects ruminants, including camels.

T. raoi (Alwar and Achuthan 1960) has been found in dromedaries in India (9).

HELMINTHOSES OF THE DIGESTIVE TRACT

Clinical and pathological features

Under natural conditions camels are practically never infested with just a single species of gastro-intestinal helminth, for multiple parasitism is the rule. With the exception of acute haemonchosis, it is practically impossible to distinguish the diseases produced by different helminths. Hence the clinical picture of these helminthoses is a combination of symptoms induced by various species. For these reasons we shall describe separately the clinical and pathological features of haemonchosis and those caused by other helminths.

(a) Haemonchosis

As with all helminthoses of the digestive tract of camels, haemonchosis caused by *H. longistipes* and/or *H. contortus* may occur throughout the year, but particularly during the rainy season.

It is generally agreed that this disease is the most severe gastro-intestinal helminthosis of camels. The clinical picture is one of anaemia associated with general illness. Symptoms develop only when the infestation is severe (more than 150 nematodes, according to Graber *et al.*, 92).

The disease is described in full by Graber *et al.* (92), Queval *et al.* (158), Altaif (8), Arzoun *et al.* (13, 14), Tager-Kagan (196), Richard (162) and Richard *et al.* (163). In general it occurs most often in young animals, and is manifested by:

- general weakness and, in lactating females, a fall in milk yield;
- anaemia recognised by pallor of the visible mucosa;
- oedema of the hollow above the eye, the sides of the sternal cushion (resulting in a characteristic and well-recognised swelling), and sometimes between the jaws;
- progressive wasting;
- sometimes depraved appetite, with ingestion of considerable amounts of sand;
- abortion (rare);
- death, which may occur after several weeks of illness.

Research on pathophysiology by Queval *et al.* (158), Ibrahim *et al.* (104), Arzoun *et al.* (13, 14) and Richard *et al.* (163) has shown that various haematological disorders

occur during haemonchosis of camels, as in other ruminants. These include falls in haematocrit, erythrocyte count, haemoglobin content, proteins, albumin, Ca, P, Mg and Cu, and increases in eosinophils, lymphocytes, neutrophils and urea content.

Pathological findings frequently include emaciation, ascites, hydrothorax and hydropericardium. There is often a lot of sand in the rumen. However, the most characteristic lesions are found in the abomasum, which has hypertrophy of the mucosa, numerous erosions and petechial haemorrhages.

(b) Other digestive system helminthoses

Clinical manifestations have been described in various publications, particularly those of Graber *et al.* (92), Ramachandran Iyer (160), Blaizot (34), Richard (161, 162), Richard *et al.* (163) and El Bihari (71). A distinction is made between light and massive infestations.

Light infestations are manifested almost exclusively by signs of diminished productivity, such as retarded growth, failure to fatten and a fall in milk yield.

Massive infestations are accompanied by a variable clinical picture, divisible into three phases: initial, advanced and ultimate.

Signs observed initially are:

- apathy
- capricious and diminished appetite
- progressive wasting, characterised by atrophy of the hump(s) and diminution of abdominal volume (the flank fold fails to fill after the animal has drunk).

At the more advanced stage there is:

- alternation of constipation and diarrhoea, or the passing of soft faeces
- more or less prominent anaemia
- colic in some animals.

In the ultimate stage the animal has difficulty in moving and can no longer eat easily, which accentuates the wasting. Death may occur after a few weeks or a few months.

Emaciation is the most striking feature at post-mortem examination, often accompanied by peritonitis. The following changes are present in the gastro-intestinal tract, their severity depending on the degree of infestation and the duration of the disease:

- abomasum: subacute or chronic catarrhal gastritis;
- small intestine: subacute or chronic catarrhal enteritis;
- large intestine: nodules ranging in size from a small pea to a small nut in the case of infestation by *Oesophagostomum* species, and/or chronic catarrhal enteritis in the case of *Trichuris* infestation.

Diagnosis

All authors agree that it is possible to establish a diagnosis from the clinical signs of severe infestation. However, haemonchosis has to be distinguished from acute

trypanosomiasis, during the course of which the animal has febrile episodes and a somnolent attitude, both normally absent from haemonchosis and the other helminthoses. By contrast, diagnosis can prove difficult in less severe cases. The symptoms described above, together with a detailed study of the case history, should be of assistance.

Diagnosis by examining faeces provides useful information, despite the limitations referred to below. According to Blaizot (34), an egg count above 600 eggs per gram of faeces indicates a number of helminths sufficient to cause physiological disorders. Graber *et al.* (92) considered that animals are severely affected if the egg count is greater than 1,000. However, many factors are responsible for producing variation in the worm egg count, regardless of the number of helminths present, including the phenomenon of hypobiosis and also nutritional and immunological factors. In the special case of oesophagostomiasis, which is a disease caused mainly by larval stages, there may be no eggs at all in the faeces.

Anthelmintic treatment

Most of the anthelmintics used in cattle and sheep for the treatment of digestive tract helminthoses can also be used in camels. A review of trials on camels (see Table I) shows that most of these drugs are capable of eliminating the various species of helminths present in the digestive tract (with a few exceptions).

Prophylaxis

As in the case of gastro-intestinal helminthoses of other animal species (particularly ruminants), prevention of those of camels can be successful only when epidemiological data are taken into account. In general terms there are two possibilities for action:

- action against free-living stages of the parasitic nematodes, which is restricted to keeping the ground around watering points as dry as possible;
- action against the parasites within the host; in this respect, Graber (90) recommends anthelmintic treatment during the dry season in order to take advantage of its sterilizing effect in reducing the contamination of grazing land, which takes place during the rainy season.

HELMINTHS AND HELMINTHOSES OF THE LIVER

HELMINTHS OF THE LIVER

Trematodes

Four species of trematodes parasitize the liver of camels:

Fasciola hepatica (Linnaeus 1758), which is one of the trematodes most frequently encountered in camels in Africa and Asia (52, 17, 125, 100, 71, 97). It has also been found in Europe (27).

F. gigantica (Cobbold 1855), a species also found in camels in Africa and Asia (52, 17, 125, 100, 13, 14, 97).

Dicrocoelium dendriticum (Rudolphi 1819), found very seldom in camels (115, 52, 17, 161, 86).

TABLE I
Anthelmintics available for treating helminthoses
of the digestive tract of camels

Anthelmintic (and route)	Dosage (mg/kg)	Reference(s)	Remarks
thiabendazole by mouth	100-150	Graber 1966	Highly effective against nematodes, although 300 mg/kg is required to eliminate <i>H. longisipes</i> and <i>Oesophagostomum</i> spp.; not all <i>Trichostrongylus</i> are eliminated
	50	Chandrasekharan <i>et al.</i> 1970	Very effective against nematodes, except for <i>Trichostrongylus</i> , not all of which are eliminated
	80	Blaizot 1975	Very effective against nematodes in general. Activity against <i>Trichostrongylus</i> not reported (1)
	90	Lodha <i>et al.</i> 1977	High efficacy against <i>Trichostrongylidae</i>
	100	Hassan <i>et al.</i> 1983	Very good efficacy against <i>Trichostrongylidae</i>
tetramisole			
— injected s.c.	10	Graber 1969	Very good efficacy against nematodes, including <i>Trichostrongylus</i>
— tablets (by mouth)	15	Chandrasekharan <i>et al.</i> 1972	Less effective against <i>S. papillosus</i> ; also active against <i>Dictyocaulus</i> spp. (1)
	15	Hassan <i>et al.</i> 1983	ditto
levamisole			
injected s.c.	7.5	Richard 1986	Very good efficacy against nematodes; also active against <i>Dictyocaulus</i> spp. (1)
morantel tartrate by mouth	3-5	Blaizot 1975	Good efficacy against nematodes; activity against <i>Trichostrongylus</i> not stated (1)
	7.5	Troncy & Oumate, 1976	Excellent efficacy against nematodes other than <i>Strongyloides</i> spp. and <i>Trichostrongylus</i> spp.
pyrantel tartrate by mouth	25	Bansal <i>et al.</i> 1969, 1971	Very good efficacy against nematodes other than <i>Trichostrongylus</i>
	25	Hassan <i>et al.</i> 1983	Highly effective against <i>Trichostrongylidae</i>
parbendazole by mouth	20	Chandrasekharan <i>et al.</i> 1971	Very good efficacy in general; activity against <i>Trichostrongylus</i> not stated (1)

TABLE I (contd.)

Anthelmintics available for treating helminthoses of the digestive tract of camels

Anthelmintic (and route)	Dosage (mg/kg)	Reference(s)	Remarks
albendazole	2.5	Richard 1986	Very good efficacy in general. Active at higher dosage (10 mg/kg) against <i>Dictyocaulus</i> spp., cestodes and adult <i>Fasciola</i> spp.
febantel by mouth	7.5	Richard 1986	Very good efficacy in general; also active against <i>Dictyocaulus</i> spp. and larval cestodes (1)
thiophanate by mouth	100	Richard 1986	Very good efficacy in general
fenbendazole by mouth	7	Selim <i>et al.</i> 1977	Excellent efficacy against nematodes; also active at higher dosage (10-15 mg/kg) against <i>Dictyocaulus</i> spp. and adult cestodes (1)
	7.5	Rutawenda & Munya 1985	ditto
	5	Bansal <i>et al.</i> 1981	Very good efficacy except against <i>Trichuris</i> spp.
oxfendazole by mouth	7	Selim <i>et al.</i> 1977	Excellent efficacy in general; also effective against <i>Dictyocaulus</i> spp. and adult cestodes (1)
	4.5	Michael <i>et al.</i> 1980	ditto
	5	Bansal <i>et al.</i> 1981	Very good efficacy except against <i>Trichuris</i> spp.; also active against <i>Dictyocaulus</i> spp. and adult cestodes
ivermectin s.c. injection	0.2	Ibrahim <i>et al.</i> 1981	Excellent efficacy, including against <i>Trichuris</i> spp.; also effective against <i>Dictyocaulus</i> spp. (1)
		Boyce <i>et al.</i> 1984	Excellent efficacy against <i>Trichostrongylidae</i> , but only 85% of <i>Trichuris</i> spp. eliminated
		Dakkak <i>et al.</i> (unpublished)	Excellent activity against nematodes in general; 91% of <i>Trichuris</i> spp. eliminated

(1) personal observation

Eurytrema pancreaticum (Looss 1907) normally occurs in the pancreatic ducts of ruminants, and less often in the bile ducts (77; Levine 1978). It is possible for camels to become infested, but rare (69, 71; Levine 1982).

Cestodes

(a) Adult stage

Stilesia hepatica (Wolffhügel 1903), found occasionally in the bile ducts (194, 100, 71).

(b) Larval stage

Hydatids of *Echinococcus granulosus* in camels are localised, as in other animals which act as intermediate hosts, in various tissues and organs, particularly liver and lung. Its geographical distribution will be dealt with below, in connexion with the respiratory system.

Cysticercus tenuicollis, larval stage of *Taenia hydatigena* (Pallas 1766), a parasite of the small intestine of domestic and wild Canidae, and sometimes cats. In camels these larvae develop in the liver and peritoneal cavity, as they do in the preferential host, sheep. They have been found only occasionally in camels (81, 92, 161).

HELMINTHOSES OF THE LIVER

Clinical and pathological features

Hepatic infestations are subclinical in camels, with the exception of heavy infestations with *Fasciola* species, which are manifested solely by vague digestive symptoms (161, 86).

From the aspect of pathology, fluke infestation is accompanied, during the migration of young flukes, by the formation of haemorrhagic tracks through liver tissue, and during the adult stage by cirrhosis and chronic cholangitis. The last two lesions can also result from infestation with *Stilesia hepatica* (191). *Eurytrema pancreaticum* can induce catarrhal inflammation, sometimes with destruction of epithelium of the pancreatic and/or bile ducts (25). The migratory stage of *C. tenuicollis* infestation results in haemorrhagic and fibrous tracks, sometimes with caseated or calcified cysticerci present. The characteristic fully-developed cysticerci ("water bladders") are usually confined to the peritoneal cavity. Hydatid cysts near the surface of the liver appear as protrusions, while those in the interior can be felt as hard lumps.

Diagnosis

A diagnosis of infestation by larval cestodes is not usually made in the live animal. The only way of detecting trematode infestations is to seek specific evidence of infestation, particularly the presence of trematode eggs in the faeces.

Anthelmintic treatment

Treatment can be applied only in those rare instances when fascioliasis is diagnosed. Several fasciolicidal drugs are currently available and may be used, although few

publications refer to their use in camels. According to Richard (161), recommended treatments are nitroxylnil at 10 mg/kg injected subcutaneously, and rafoxanide at 7.5 mg/kg by mouth. These two anthelmintics are also effective, in the same dosage, against myiasis of the nasal cavity (particularly *Cephalopina titillator*) and blood-sucking nematodes. Albendazole, already mentioned for treating gastro-intestinal helminthoses, is also effective against *Fasciola* spp. at a dose rate of 10 mg/kg.

Prophylaxis

Although from a pathological viewpoint, infestation with hydatids of *E. granulosus* does not have serious consequences for camels, it is one of the major helminthoses from the viewpoint of public health. In fact, these animals act as important sources of infestation for dogs, thereby indirectly threatening human beings, in whom hydatidosis is a serious and even fatal disease. It is therefore necessary to limit this threat to human health by excluding dogs from places where camels are slaughtered, and by seizure and destruction of any organ bearing hydatid cysts.

The prophylaxis of other helminth infestations of the liver of camels does not arise.

HELMINTHS AND HELMINTHOSES OF THE RESPIRATORY TRACT

HELMINTHS PARASITIC IN THE RESPIRATORY TRACT

Nematodes

Infestation of camels by lungworms is possible but rare.

Dictyocaulus filaria (Rudolphi 1809) is the nematode which is encountered most frequently in the respiratory tract of camels, having been found in Africa (154, 52, 182, 127, 80), Asia (52, 182, 36, 100) and Europe (205, 83).

D. cameli (Boev 1951) is specific for camels, and has been found only in Asia (35, 175, 182, 198).

Cestode larvae

Only the hydatids of *Echinococcus granulosus* are capable of developing in the respiratory tract. These larvae occur principally in the lungs and liver, but they may also be found in other tissues and organs. The following geographical distribution includes all localisations:

North Africa: here the highest incidence has been recorded (101, 38, 62, 24, 50, 143, 144, 145, 31, 49, 42, 43, 141, 7, 16, 58).

East Africa: the parasite is frequently encountered here (140, 195, 193, 194, 70, 95, 73, 127, 3, 106, 161, 61, 96, 128, 168).

Central Africa: the incidence is rather lower than in other parts of Africa (89, 91, 92, 200, 196, 163). In Nigeria, Dada (53), Dada and Belino (54, 55) and Dada *et al.* (56) reported infestation rates close to 50%. Infestation of camels has also been reported from Mauritania by Morel (133) and from Mozambique by Simitch (176).

Asia: the rate of infestation seems to be highest in the South-West (153, 197, 206, 105, 59, 4, 131, 8, 99, 6, 202, 10, 1). It also occurs frequently in Central Asia (37, 76, 5, 108) and India (93, 123).

RESPIRATORY HELMINTHOSES

Clinical and pathological features

From the clinical aspect, infestations with hydatids of *E. granulosus* pass unobserved. Severe infestation with *Dictyocaulus* spp. is accompanied by general malaise and signs of functional disorders, the latter comprising cough and polypnea, rapidly becoming complicated by dyspnea. General symptoms are apathy and anorexia, with a fall in productivity as a result.

Lungs harbouring hydatid cysts near the surface show protuberances. Within the lung tissue they can be felt as hard lumps, not very mobile. Dictyocauliasis is accompanied by an abundance of white and foamy mucus, perhaps mixed with pus. The nematodes become intertwined and form balls held together by mucus.

Diagnosis

In the living animal, diagnosis can be performed only in the case of dictyocauliasis, from the symptoms described above and the presence of larvae in the faeces.

Anthelmintic treatment

Anthelmintics suitable for treating dictyocauliasis are listed in Table I.

Prophylaxis

It is necessary to implement control measures against the hydatids of *E. granulosus*, as described earlier. In camels the lungs are more likely to be infested than any other organ.

The only means of preventing dictyocauliasis is to attack the parasites within the host by prophylactic administration of anthelmintics active against these nematodes (see Table I).

HELMINTHS AND HELMINTHOSES OF THE CIRCULATORY SYSTEM

HELMINTHS PARASITIC WITHIN THE CIRCULATORY SYSTEM

Trematodes

Schistosoma bovis (Sonsino 1876) occurs in the mesenteric veins and the portal vein, occurring in Africa (127, 184, 89, 91, 92) and Saudi Arabia (187, 189).

S. indicum (Montgomery 1906) is an Asiatic species which occurs in the portal, mesenteric, hepatic, pancreatic and pelvic veins (78) of camels in India and Pakistan (138, 177, 78, 191).

S. mattheei (Veglia and Le Roux 1929) occurs in the portal, and mesenteric veins, also in veins of the stomach and urogenital system. It has been found among camels in Saudi Arabia (189).

Orientobilharzia turkestanicum (Skrjabin 1913) parasitizes the mesenteric and portal veins of camels in Iraq (124) and Iran (12).

Nematodes

Dipetalonema evansi (Lewis 1882) is a filarial nematode specific for camels, developing in the heart and in hepatic, pulmonary and spermatic arteries, as well as lymph nodes and lymphatics. The microfilariae feed on blood.

In Africa it has been identified in the East (135, 193, 194, 70, 187, 2, 208, 174) and the North (173, 156, 190).

In Asia it has been identified in India and Pakistan (79, 119, 113, 30, 40, 190) and in USSR (207, 190, 37, 57).

Onchocerca armillata (Railliet and Henry 1909) develops within the aorta, particularly in cattle. It has been found in this location in dromedaries in Nigeria (169).

HELMINTHOSES OF THE CIRCULATORY SYSTEM

Clinical and pathological features

There are no clinical signs of infestation with *Schistosoma* spp. and/or *Orientobilharzia turkestanicum* in camels, and the same applies to light infestations with *D. evansi*. However, massive infestation with this filarial nematode produces emaciation, apathy and sometimes orchitis and nervous symptoms (cerebral anaemia).

Diagnosis

Filarial nematodes within arteries cannot be detected clinically. Any clinical manifestations which may arise can be confused with those of trypanosomiasis, although the latter is accompanied by torpor and febrile episodes, which are absent from filarial infestations.

Lesions produced by the parasites in the circulatory system are not specific, unless they settle in the spermatic artery, where they can produce aneurysm leading to epididymitis and orchitis.

Anthelmintic treatment and prophylaxis

Good results have been obtained in the USSR with Fouadin (stibophen) at 0.5 mg/kg body weight, injected intravenously for both therapeutic and prophylactic purposes, as prevention during the period of activity of the mosquito intermediate host, *Aedes detritus*.

HELMINTHS AND HELMINTHOSES OF THE NERVE CENTRES

HELMINTH PARASITES OF NERVE CENTRES

Coenurus cerebralis is the larval stage of *Taenia multiceps* (Leske 1780) which occurs in the small intestines of Canidae (particularly dogs). It has been found within the brain of camels by Droandi (68), Neveu-Lemaire (138, 139), Curasson (52) and Burgmeister *et al.* (45).

HELMINTHOSES OF NERVE CENTRES

Clinical and pathological features

Development of *Coenurus* in the nervous system produces noticeable changes in behaviour, with diminution of appetite (or even anorexia), depression, unwillingness to move or difficulty in walking; the animal may make circling movements.

Diagnosis

Clinical diagnosis is possible, although coenurosis has to be distinguished from myiasis of the respiratory passages caused by *Cephalopina titillator*. The latter produces excitement, sneezing and snorting (209) and sometimes abnormal behaviour similar to that occurring in coenurosis.

Treatment and prophylaxis

No drug therapy is available. Prophylaxis consists of destroying any *Coenurus* found at slaughter, although this applies mainly to sheep, because the skull of camels is not usually opened at slaughter. The adult form in dogs can be controlled by using one of the cestodicidal or cestodifugal anthelmintics currently available.

HELMINTH PARASITE OF THE EYE

There is a specific parasite of the eyes of camels, *Thelazia leesei* (Railliet and Henry 1910), a nematode which develops within the conjunctival sacs. This spirurid nematode has been found in Asia (165, 64, 65, 57, 5) and Africa (165).

This parasitism seems to be well tolerated by camels. One or both eyes may be affected, but without showing much change. Prophylaxis is based on combatting flies of the genus *Musca* which act as intermediate hosts.

HELMINTH PARASITES OF MUSCLES

In camels the larval stages of two cestodes may be found in muscle tissue:

Cysticercus dromedarii (Pellegrini 1942), the larval stage of *Taenia hyaena* (Baer 1924), a parasite of the small intestine of various African species of hyaena. Antelopes are the usual intermediate hosts. In dromedaries, these larvae were found in Somalia by Pellegrini (148, 149, 150, 151, 152), and they have also been found in Egypt (81) and Chad (92).

Cysticercus bovis (Cobbold 1866) is the larval stage of *Taenia saginata*, a tapeworm of the small intestine of human beings. Bovines are the usual intermediate hosts, and infestation of camels is very rare (92, 161).

Infestation of muscle tissue by cysticerci is not usually manifested by any detectable clinical sign.

Prophylaxis requires the prevention of infection of camels by anthelmintic treatment of human beings for *Taenia saginata* infestation. Human infestation, which takes place through eating camel meat as well as beef, is preventable by correct meat

inspection, applied to the heart, masseter muscles and tongue. Any carcass infested with cysticeri must be condemned as unfit for human consumption, or cooked sufficiently to destroy the cysticeri.

HELMINTH PARASITES OF SUBCUTANEOUS CONNECTIVE TISSUE AND THE NUCHAL LIGAMENT

Two species of filarial nematodes of the genus *Onchocerca* have been identified in camels:

Onchocerca fasciata (Railliet and Henry 1910), a parasite of subcutaneous connective tissue and the nuchal ligament, is specific for camels according to Sonin (190), and it occurs in Africa (Sudan, Ethiopia, Kenya, Mauritania) and Asia (USSR and India). Its occurrence and clinical manifestations in Saudi Arabia have been described recently by Bain and Nasher (20) and Cheema *et al.* (48).

O. gutturosa (Neuman 1910) develops in subcutaneous connective tissue, the nuchal ligament and other tissues, such as the scapular cartilage. It is mainly a parasite of cattle, but has also been found in camels (75).

Affected animals have skin nodules on various parts of the body, particularly on the head and neck (48). The nodules are firm, not sensitive to the touch, and range from 0.5 to 4 cm in diameter; they have a fibrous capsule. The filaria can be seen when a nodule is cut open, perhaps accompanied by pus. The animals seem to tolerate this infestation without adverse effect.

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REFERENCES

(See p. 439)
