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NERVOUS TISSUE LESIONS CAUSED BY ELAPHOSTRONGYLOSIS IN WILD SWEDISH MOOSE

By

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STEEN, MARGARETA and CLAES REHBINDER: *Nervous tissue lesions caused by elaphostrongylosis in wild Swedish moose.* Acta vet. scand. 1986, *27*, 326—342. — During the first 5 months of 1985, 35 moose were obtained for necropsy at the National Veterinary Institute, Uppsala, Sweden. 17 (49 %) of these cases were found to be infected with Elaphostrongylus sp. The nematodes were found in the epidural space of the spinal cord and brain, around and in the sciatic nerves and in muscle fasciae. Predilection sites appeared to be near cauda equina and the fasciae of the thoracic, gracilis and sartorius muscles.

Most of the infected animals were calves. Both sexes were equally represented. Pathological changes found were characterized by focal haemorrhages and oedema. The changes were present in the muscle fasciae and in the leptomeninges of the brain and spinal cord. Beside infiltrates of mainly lymphocytes and plasma cells, adult nematodes, larvae and eggs were observed.

Cases with mild gliosis in the cerebrum and degenerative changes of peripheral nerve roots affecting the epi- and perineurium were also found. In one case the inflammatory changes reached the endoneurium of a sciatic nerve bundle and in another case into a ganglion.

Inflammatory reactions against the parasite were mainly directed towards eggs. In loose connective tissue close to nerve tissue in the central nervous system larvae were found close to eggs and remains of eggs indicating that eggs may hatch at this site.

This investigation shows that natural infections with Elaphostrongylus sp. occur in wild moose and may produce pathological changes in large peripheral nerves and in the central nervous system.

moose; elaphostrongylus; nematode; nervous lesion.

In April 1984 a 10-month-old moose calf found dead, was submitted for necropsy at the National Veterinary Institute, Uppsala, Sweden. At necropsy the calf was emaciated and several Elaphostrongylus sp. were found in the epidural space of the spinal cord but also in muscle fasciae.

During the first five months of 1985 moose from several localities in the middle and northern parts of Sweden were reported dead, their total number exceeding 200. Most of the dead animals were found within a few rather limited areas. In addition most of the dead animals were calves.

MATERIAL AND METHODS

During winter and spring 1985 carcasses of 35 moose were obtained. The material comprised both sexes and different age groups (Table 1).

At necropsy the brain was removed and the spinal cord was exposed along its whole length and removed. The sciatic nerves were dissected free and the muscle-bundles of the whole body were macroscopically examined.

Macroscopically affected areas of the brain, spinal cord, sciatic nerves and muscle fasciae were fixed in 10 % formalin after being examined for the presence of parasites.

After fixation tissues were embedded in paraffin, sectioned 4 μm and stained with haematoxylin eosin and v. Gieson.

For measuring adult nematodes were placed in saline on glass slides and mounted under cover-slips ringed by vaseline. 6 females and 2 males were measured.

Larvae from faeces and lungs were collected from 11 animals. They were investigated by means of Baermann technique. The larvae found were kept in water at 4°C and studied after they had been immobilized by mild heat and mounted under cover-slips ringed by vaseline.

RESULTS

The necropsied moose represented both sexes, 11 males and 24 females. The nutritional state varied: 26 animals were emaciated, 1 was in a poor nutritional state, while 8 appeared to be in normal nutritional state (Table 1).

In 2 cases the necropsy was entirely negative. Emaciation without any signs of underlying disease was found in 1 case.

In 17 (49 %) of the 35 animals necropsied the only pathological changes found were due to elaphostrongylosis, defined to the finding of adult nematodes; out of these moose, 1 was in normal and 1 in moderate nutritional state while 15 animals were

Table 1. Necropsy findings in moose obtained January-May 1985 at the National Veterinary Institute.

Necropsy no.	Date	Age	Sex	Nutritional state	Diagnosis	Comments
V 13	4/1-85	c. 6yrs	♀	Normal	Pneumonia	Found dead, still warm, the ground around was damaged by her own action
V 20	7/1-85	c. 7 m.	♂	Normal	Negative section	Found dead
V 220	12/2-85	c. 8 m.	♂♀	Inanition	Elaphostrongylosis	Found dead, still warm
V 290	19/2-85	18 yrs	♀	Inanition	Worn out teeth	Found dead
V 441	4/3-85	c. 9 m.	♀	Inanition	Traumata	Found dead
V 563	13/3-85	9.5yrs	♀	Inanition	Protostrongylidae/ Nerve degeneration	Found dead
V 607	14/3-85	>15yrs	♀	Inanition	Tumour	Strange behaviour, showed no fear of people
V 704	21/3-85	>10yrs	♀	Poor	Parasites	Found dead
V 712	25/3-85	>6yrs	♀	Inanition	Traumata	Seen alive, dead after a few hours
V 750	2/4-85	10yrs	♀	Inanition	Discospondylosis	Found dead
V 773	3/4-85	c. 10 m.	♀	Inanition	Traumata/Fibroma	Killed with a hammer
V 792	10/4-85	c. 10 m.	♀	Inanition	Elaphostrongylosis	Found dead, two incisors broken
V 829	12/4-85	c. 10 m.	♀	Moderate	Elaphostrongylosis	Several dead moose found in the area
V 830	12/4-85	14.5yrs	♀	Inanition	Elaphostrongylosis	Several dead moose found in the area
V 834	15/4-85	c. 10 m.	♂♀	Inanition	Traumata	
V 885	18/4-85	c. 6yrs	♀	Normal	Mucosal disease	Belonged to control group in a study of the moose population
V 901	22/4-85	11.5yrs	♀	Normal	Negative section	
V 1014	26/4-85	5yrs	♀	Inanition	Ulcerative stomatitis	Observed in a bad condition, died after a couple of hours, 20 more moose found dead in the surrounding
V 1016	26/4-85	c. 10 m.	♂	Inanition	Elaphostrongylosis	Lesions around the eyes
V 1033	30/4-85	4yrs	♂	Normal	Circulatory collapse/ stress	Observed very stressed during a cross-country orientation competition
V 1064	7/5-85	c. 11 m.	♂	Inanition	Elaphostrongylosis	3 calves found dead in the same area
V 1065	7/5-85	c. 11 m.	♀	Inanition	Elaphostrongylosis	"
V 1066	7/5-85	c. 11 m.	♂♀	Inanition	Elaphostrongylosis	"
V 1071	8/5-85	c. 11 m.	♀	Inanition	Cephenemyia ulrichii	Killed due to its very bad condition and strange behaviour
V 1073	8/5-85	c. 11 m.	♂	Inanition	Elaphostrongylosis	Several dead moose found in the area
V 1079	9/5-85	c. 11 m.	♂	Inanition	Elaphostrongylosis	Found dead
V 1081	9/5-85	c. 11 m.	♀	Inanition	Elaphostrongylosis	Found dead
V 1090	10/5-85	c. 11 m.	♀	Inanition	Elaphostrongylosis	Found dead. The day before it had been lying in the same place, still alive
V 1096	13/5-85	18yrs	♀	Inanition	Inanition	Two more moose found dead
V 1123	15/5-85	c. 11 m.	♂	Inanition	Elaphostrongylosis	The calf was seen falling down dead
V 1124	15/5-85	c. 11 m.	♀	Inanition	Elaphostrongylosis	Seen alive the day before it was found dead
V 1138	20/5-85	c. 11 m.	♂♀	Inanition	Elaphostrongylosis	Found dead
V 1173	29/5-85	7.5yrs	♀	Normal	Ulcerative stomatitis	Found dead
V 1176	30/5-85	c. 11 m.	♀	Normal	Elaphostrongylosis	Were stuck in a barbed-wire fence and died
V 1188	30/5-85	16.5yrs	♂	Inanition	Elaphostrongylosis	there 70 dead moose were found in the area

Table 2. Necropsied moose with elaphostrongylosis obtained Jan-May 1985 at the National Veterinary Institute. Low age and inanition are overrepresented in these animals when compared with other moose obtained for necropsy.

Necropsy number	Date	Age	Sex	Nutritional state	Elaphostrongylus sp. in the central nervous system	Elaphostrongylus sp. in the fasciae of the skeletal muscular	Nematode eggs in the central nervous system	Protostrongylidae larvae in lungs	Macroscopic lesions in the central nervous system	Microscopic lesions in the central nervous system
V 220	12/2-85	c. 8 m.	♀	Inanition	+	+	+	+	+	+
V 792	10/4-85	c. 10 m.	♀♀	Inanition	+	+	÷	+	+	÷
V 829	12/4-85	c. 10 m.	♀♀	Moderate	+	—	÷	+	÷	÷
V 830	12/4-85	14.5 yrs	♀♀	Inanition	—	+	÷	+	÷	÷
V 1016	26/4-85	c. 10 m.	♂♂	Inanition	+	+	—	+	+	+
V 1064	7/5-85	c. 11 m.	♂♂	Inanition	+	+	—	÷	+	+
V 1065	7/5-85	c. 11 m.	♂♂	Inanition	+	+	—	÷	+	+
V 1066	7/5-85	c. 11 m.	♂♀	Inanition	+	+	+	÷	+	+
V 1073	8/5-85	c. 11 m.	♂♂	Inanition	+	—	—	+	+	+
V 1079	9/5-85	c. 11 m.	♂♂	Inanition	+	+	+	÷	+	+
V 1081	9/5-85	c. 11 m.	♀♀	Inanition	+	—	+	÷	+	+
V 1090	10/5-85	c. 11 m.	♀♀	Inanition	+	—	—	÷	+	+
V 1123	15/5-85	c. 11 m.	♂♂	Inanition	+	+	+	+	+	+
V 1124	15/5-85	c. 11 m.	♂♀	Inanition	+	+	+	+	+	+
V 1138	20/5-85	c. 11 m.	♂♂	Inanition	+	+	—	+	+	+
V 1176	30/5-85	c. 11 m.	♀♀	Normal	+	—	—	+	+	+
V 1188	30/5-85	16.5 yrs	♂	Inanition	+	—	—	—	+	+

Comments
+ = positive
— = negative
÷ = not investigated

V 220/85 Found dead. Still warm.
V 792/85 Found dead. Two incisors broken.
V 829/85 Found dead. Several dead moose found in the area.
V 830/85 „
V 1016/85 Lesions around the eyes.
V 1064/85 3 calves found dead in the same area.
V 1065/85 „
V 1066/85 „
V 1073/85 Several dead moose in the area.
V 1079/85 Found dead.
V 1081/85 „
V 1090/85 Found dead. The day before it had been lying in the same place, still alive.
V 1123/85 The calf was seen falling down dead.
V 1124/85 Seen alive the day before it was found dead.
V 1138/85 Several moose found in the area with diagnosis elaphostrongylosis.
V 1176/85 Was found stuck in a barbed-wire fence and died there.
V 1188/85 70 dead moose were fund in the area.

emaciated. For the remaining animals the cause of death could be related to other diseases or traumata.

It is notable that in the group of moose infected with Elaphostrongylus sp. emaciation and low age were overrepresented (Table 2).

Gross pathology

In each of the infestated 17 animals, 1—30 adult Elaphostrongylus sp. were found. Adult nematodes were found in the central nervous system of 16 animals. In 11 of the examined moose, however, nematodes were found mainly on the fasciae between muscle bundles. Predilection sites appeared to be the fasciae of the superficial thoracic muscles and fasciae between the gracilis and sartorius muscles. The findings were usually associated with haemorrhages and oedema with a diameter of 1—2 cm.

In the central nervous system most of the nematodes were found in the epidural space of the spinal cord laying mainly close to the Filum terminale (Fig. 1). In one case a single adult Elaphostrongylus sp. was found in the subdural space between the cerebrum and the cerebellum.

Histology

N e r v o u s t i s s u e. In the central nervous system inflammatory changes were regularly seen. Several cases showed focal inflammatory processes in the leptomeninges of the brain (Fig. 2). They were usually mild, characterized by infiltration of lymphocytes, plasmacells and macrophages. The macrophages often contained yellowish detritus masses resembling hemosiderin. In one animal an adult parasite was found in the subdural space of the cerebrum. It was surrounded by a mild infiltration of lymphocytes. Foci of mild gliosis of the cerebrum were present in 6 cases.

Furthermore, in 14 cases the leptomeninges of the spinal cord revealed focal inflammatory processes with marked infiltrations of lymphocytes, plasmacells and macrophages containing detritus. Present were also free yellowish granular detritus masses, oedema and haemorrhages.

The inflammatory changes in the meninges sometimes extended to the roots of the spinal nerves. In some areas mild

Figure 1. Adult Elaphostrongylus sp. in the epidural space of the spinal cord close to a spinal nerve root (arrows). Note the haemorrhage.

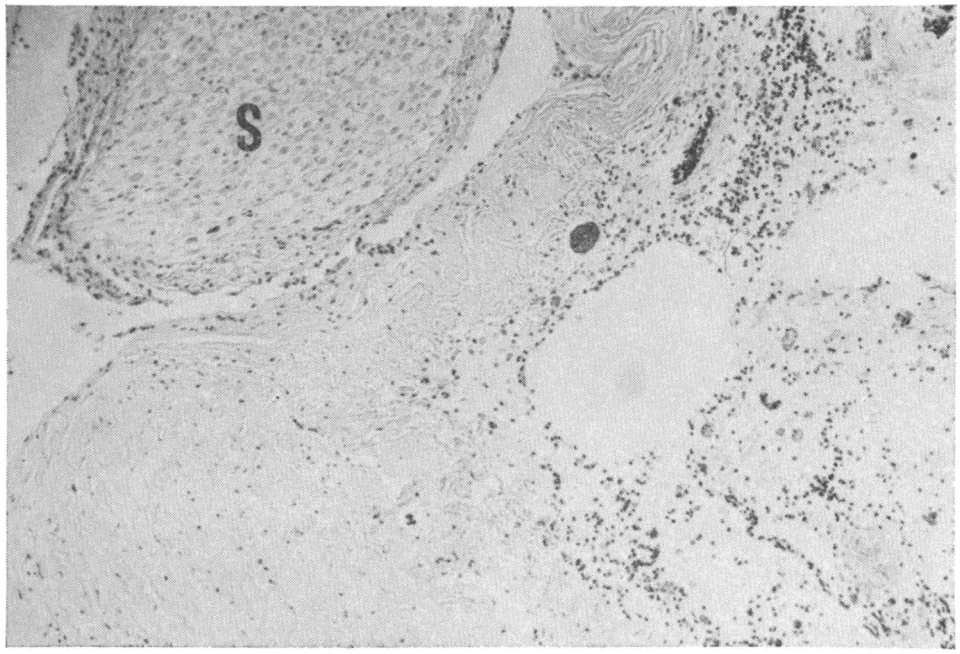


Figure 2. Inflammatory changes reaching the root of a spinal nerve (S). HE × 35.

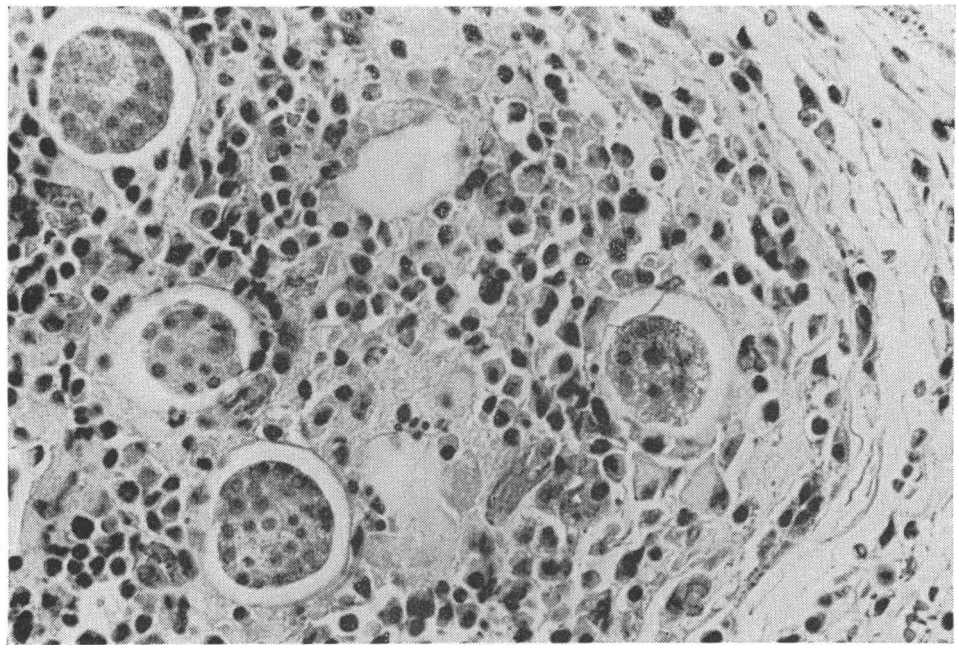


Figure 3. Egg granuloma. The granuloma is surrounded by a thin capsule of loose connective tissue. In the center eggs are present in vacuoles lined by a thin lamina and surrounded by mononuclear and epithelioid cells. HE × 560.

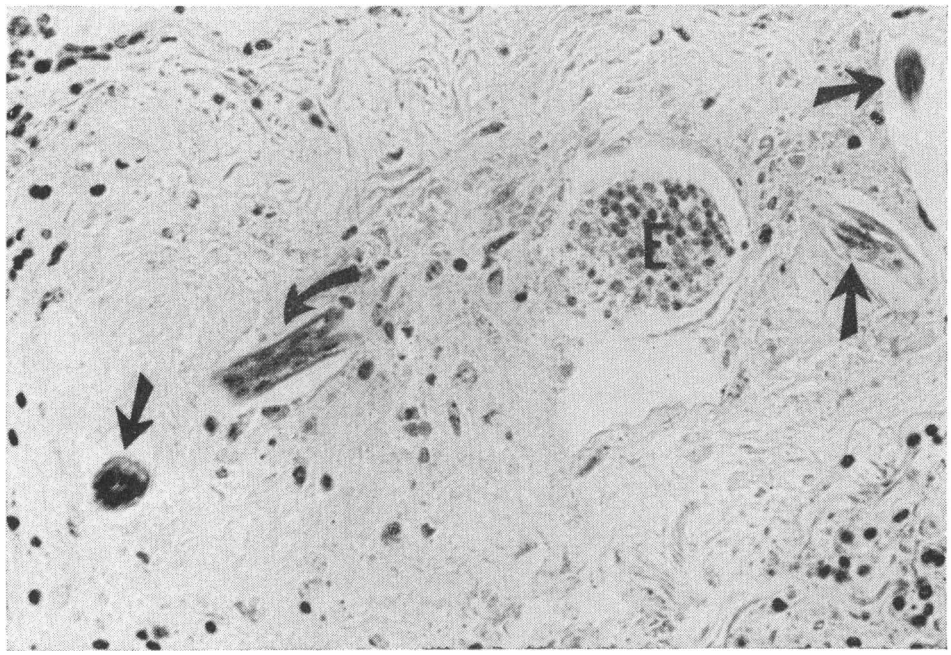
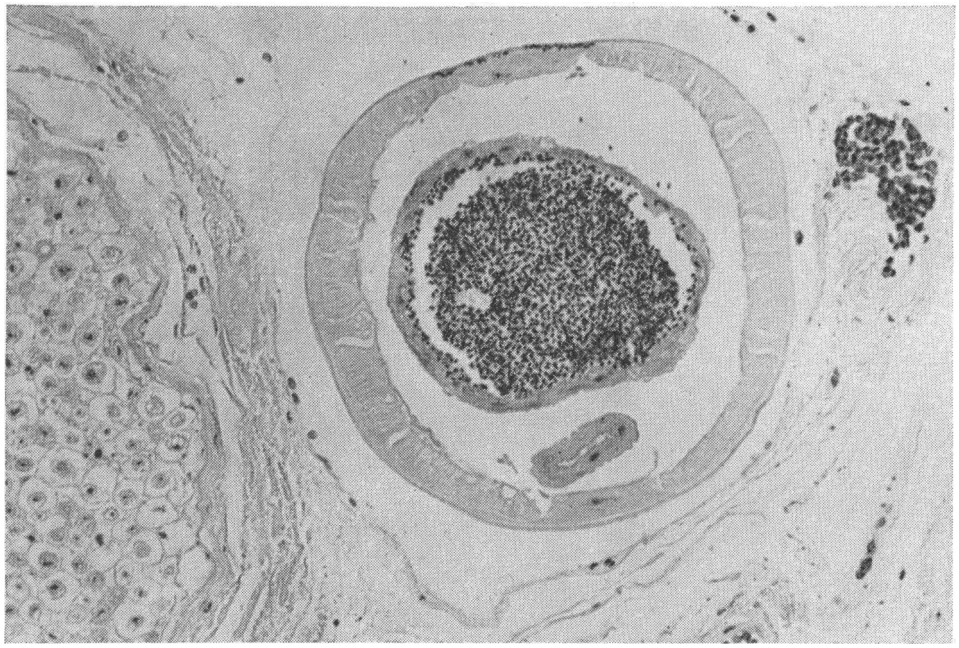
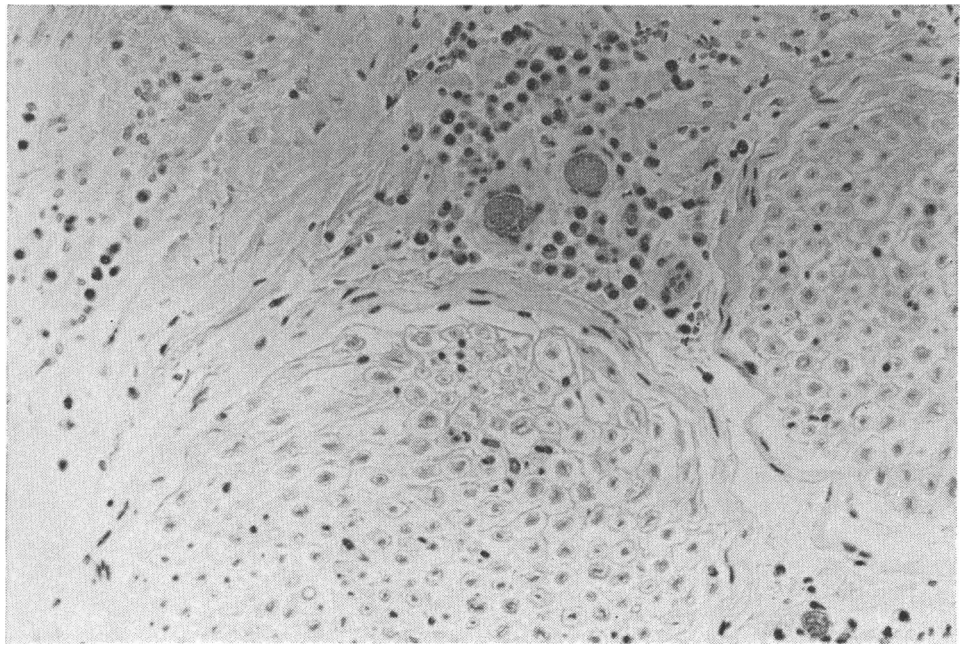


Figure 4. Hatched larvae (arrows) close to an egg (E) granuloma. HE × 240.



F i g u r e 5. Cross section of an adult Elaphostrongylus sp. close to a nerve bundle. The inflammatory response is low. HE × 240.



F i g u r e 6. Diffuse infiltration of mononuclear cells extending into nerve tissue. The infiltration affects the epi-, peri- and endoneurium. Eggs are seen in the loose connective tissue between the nerve bundles. HE × 240.

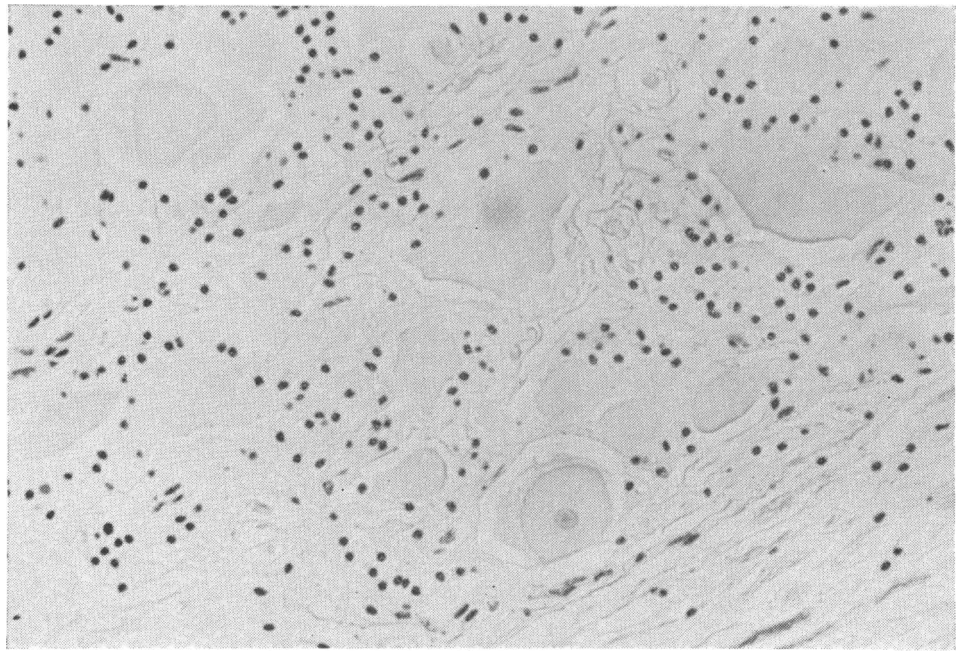


Figure 7. A nerve ganglion with diffuse infiltration of mononuclear cells. Ganglion cells are in a late stage of degeneration. HE × 240.

Figure 8. Caudal end of an adult male of Elaphostrongylus sp. × 10.

degenerative changes with infiltration of lymphocytes were noticed (Fig. 3). In the area of Filum terminale, granuloma formations around eggs of Elaphostrongylus sp. were frequently found. The granulomas had a thin capsule of loose connective tissue. In the center of the granulomas, eggs, which were laying in clumps, were present in vacuoles lined by a thin lamina and surrounded by infiltrates of mainly lymphocytes, plasmacells and epithelioid cells (Fig. 4). In some granulomas hatched larvae and remains of eggs were detected (Fig. 5).

Also in the loose connective tissue between nerve bundles in the roots of spinal nerves, adults, larvae and eggs of Elaphostrongylus sp., and granulomas were observed. The location was mainly close to the roots of the sciatic nerves.

The inflammatory response towards adults and larvae of Elaphostrongylus sp. was usually none or mild (Figs. 5 and 6), whereas inflammatory reactions towards eggs were pronounced (Fig. 4).

Diffuse infiltration of the mononuclear cells was in some cases found to extend into nerve tissue affecting the epi-, peri- and endoneurium (Fig. 7). Similar changes were also found in one ganglion (Fig. 8).

Some of the lesions close to eggs and larvae gave the impression of a tunnel or track lined with inflammatory cells, bleedings and detritus masses.

F a s c i a e. In the fasciae, areas with a marked infiltration of lymphocytes, plasmacells and macrophages were regular findings. In these areas haemorrhages and numerous dilated capillaries were seen, but also granular, yellowish, hemosiderin-like detritus masses. The latter were to a large extent present in macrophages, but also laying free. Larvae and eggs of Elaphostrongylus sp. and tunnel-formations were sometimes found. Adults were not infrequently found in these areas.

Parasitology

E l a p h o s t r o n g y l u s s p. The description of the adult nematode is based on a study of 2 male and 6 female specimens.

M a l e. Length 290 and 330 mm. Width 0.190 and 0.240 mm. Spiculae short and stout. In one the spiculae were of equal length, 0.175 mm. In the other unequal 0.160 resp. 0.180 mm. Bursa high

developed, entire, 0.180 mm wide. Dorsal ray with a stout base, bifurcated into two, nearly parallel, branches.

Female. Length 550—630 mm. Width 0.250—0.260 mm. Excretory pore 0.580—0.620 mm from anterior end. Vulva 0.190 mm and anus 0.050 mm from posterior end. Female tail tip bluntly conical. Provagina absent.

First-stage larvae. Dorsal spine present.

Following classification keys by either *Anderson* (1978) or by *Yamaguti* (1961) the nematode is defined to the genus Elaphostrongylus.

DISCUSSION

In 1930 a nematode about 5 cm long was observed in the fasciae beneath the M. latissimus dorsi of a Scottish deer (Cervus elaphus L.) by *Miller* (1931). The nematode was given the name Elaphostrongylus cervi by *Cameron* (1931). Later two more species have been described, Elaphostrongylus panticola(*Liubimov* 1945) from red deer in Asia (Cervus elaphus sibiricus) and Elaphostrongylus rangiferi (*Mitskevich* 1958) from reindeer (Rangifer tarandus tarandus L.).

The taxonomical position of these nematodes is, however, not clarified. *Kutzer & Prosl* (1975) stated Elaphostrongylus panticola to be synonymous with Elaphostrongylus cervi. They also considered Elaphostrongylus rangiferi to be synonymous with Elaphostrongylus cervi. *Pryadko & Boev* (1971) considered Elaphostrongylus cervi, Elaphostrongylus panticola and Elaphostrongylus rangiferi to be subspecies. The dividing into species of the genus Elaphostrongylus has apparently been more related to the different cervidae hosts than to differences in the morphology. This division into species has been questioned (*Lankester & Northcott* 1979). It the present investigation the identity of Elaphostrongylus is so far not taxonomically clarified.

Elaphostrongylus spp. have been described in various cervidae of the world, as red deer (Cervus elaphus L.) (*Cameron* 1931, *Kutzer & Porsl* 1975, *Mason et al.* 1976, *Borg* 1979, *Helle* 1980, *Watson* 1983), wapiti (Cervus elaphus canadensis) (*Mason* 1976), reindeer (Rangifer tarandus tarandus L.) (*Roneus & Nordkvist* 1962, *Nordkvist et al.* 1962, *Bakken & Sparboe* 1973, *Kummeneje* 1974), fallow deer (Dama dama L.) (*Sugar* 1978),

roe deer (Capreolus capreolus L.) (*Nilsson* 1971, *Borg* 1975, *Kutzer & Prosl* 1975, *Sugar* 1978) and moose (Alces alces L.) (*Nilsson* 1971, *Borg* 1975, *Holt* 1982, *Halvorsen & Wissler* 1983, *Roneus et al.* 1984).

In some reports Elaphostrongylus cervi is considered rather apatogen causing only minor lesions (*Mason* 1976, *Sutherland* 1976, *Prosl & Kutzer* 1980).

In Austrian red deer, despite the occurrence of Elaphostrongylus cervi in the subdural and subarachnoidal space, *Prosl & Kutzer* (1980) did not find any histopathological lesions. The only lesions found were connected with larvae of Elaphostrongylus cervi in the lungs.

Sutherland (1976) described gross and histopathological lesions in the connective tissues, lymph nodes and lungs. These lesions varied, from mild infiltrations of eosinophils to granulomas with a central necrosis. In the lungs larvae were observed to produce a diffuse interstitial pneumonia, consolidation and focal emphysema. Lesions in the central nervous system were not observed.

Clinical disease and pathological lesions in connection with Elaphostrongylus sp. infections, however, have been reported by several authors.

Schwangart (1940) found Elaphostrongylus nematodes in the brain and spinal cord of a paralysed red deer.

Lankester (1977) reported of an experimental infection in moose with larvae of Elaphostrongylus cervi obtained from caribou. Neurological signs with pronounced weakness affecting the hindlimbs were seen. At necropsy adult Elaphostrongylus nematodes were found associated with the brain and spinal cord. *Lankester* states that the tissue damage caused by the parasites in the central nervous system was undoubtedly responsible, at least in part, for the pronounced neurological signs exhibited.

In 1979 *Borg* described a case of paralysed hindquarters in a red deer calf from a zoo in Sweden. The postmortal examination revealed the presence of Elaphostrongylus cervi in the region of the cerebellum.

Watson (1983) reported on clinical signs i.e. exercise intolerance, blindness, hindlimb incoordination and occasional nervous disorder in 17 red deer infected with larvae of Elaphostrongylus cervi. He also noticed clinical disease associated with verminous pneumonia and a severe pulmonary haemorrhage.

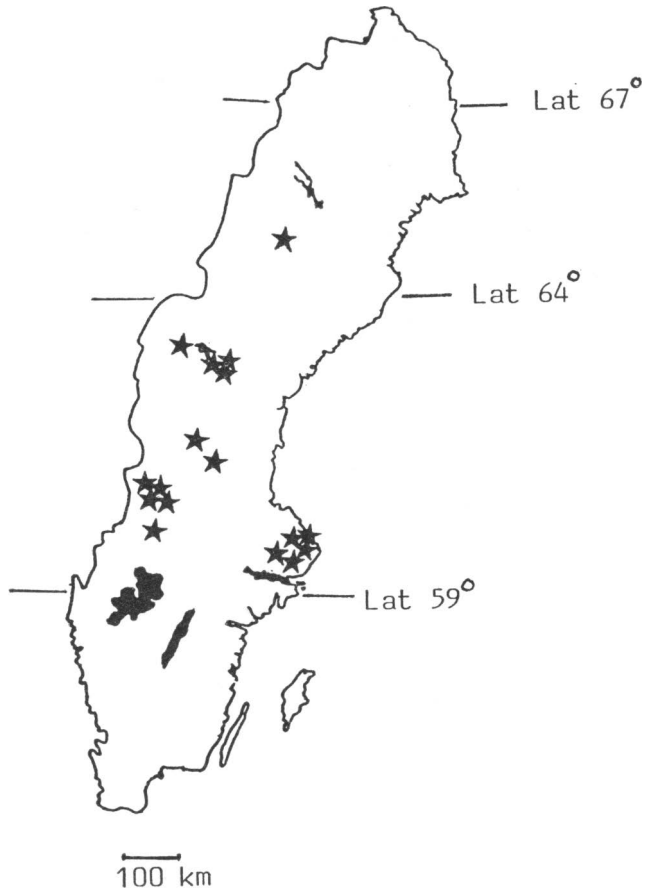


Figure 9. Map of Sweden. The locations of findings of moose infected with Elaphostrongylus sp. are indicated.

In reindeer Elaphostrongylus rangiferi is well known to cause morbidity as well as mortality characterized by central and peripheral nervous lesions and pneumonia (*Roneus & Nordkvist* 1962, *Bakken & Sparboe* 1973, *Kummeneje* 1974).

The parasites are established in large parts of different reindeer populations, sometimes giving rise to a considerable mortality but sometimes obviously not resulting in an increased morbidity or mortality. In reindeer mostly calves are clinically affected although most adults are infected (*Nordkvist et al.* 1962, *Bakken & Sparboe* 1973, *Kummeneje* 1974).

Also in our material young animals seem to be moore prone to suffer from Elaphostrongylus infections (Table 2).

In the present investigation lesions were found similar to those described by *Lankester* (1977).

Inflammatory lesions were found to be more frequently connected with the presence of eggs than with larvae or adult nematodes. The eggs also produced multiple granulomas, with large amounts of mononuclear and epitheloid cells, in the leptomeninges and in loose connective tissue between nerve bundles.

Larvae were often found in close connection with eggs. Sometimes eggs, remains of eggs and larvae were found within the same granulomas. This indicates that eggs of this particular species of Elaphostrongylus do hatch in loose connective tissue as reported by *Vsevolodov & Pryadko* (1964) and *Barus & Blazek* (1973).

The finding of hemosiderin-like granulae in this investigation correspond to reports on red deer infected with Elaphostrongylus cervi (*Dykova'* 1969). Probably these detritus masses are the excrements of the nematode.

It is indicated, from the lesions found and the preponderance of emaciation among the infested animals, that neurological disorder due to elaphostronglyolsis could be the cause of emaciation and death of moose.

The present investigation and earlier observations (*Roneus et al.* 1984, *Nilsson* in manuscript) indicate that Elaphostrongylus sp. is widely distributed in Swedish moose population (Fig. 10). However, the observations are still few and the infection rate is thus yet unknown.

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SAMMANFATTNING

Nervvävnadsskador orsakade av elaphostrongylos hos viltlevande älg i Sverige.

Under de 5 första månaderna 1985 inkom 35 älgar till Statens Veterinärmedicinska Anstalt, Uppsala, för obduktion. Hos 17 av dessa (49 %) påvisades infektion med Elaphostrongylus sp.

Nematoderna påträffades epiduralt på ryggmärg och hjärna, runt och i ischiadicusnerver samt vid muskelfascier. Predilektionsställen var i anslutning till cauda equina samt intill fascier för pectoral-, gracilis- och sartoriemusklerna. Av de infekterade djuren utgjordes huvuddelen av kalvar. Båda könen var likvärdigt representerade. De patologiska fynden karakteriserades av fokala blödningar och ödem. Förändringarna förelåg i muskelfascier samt i hjärnans och ryggmärgens leptomeninger. De histologiska fynden utgjordes av infiltrat med huvudsakligen lymfocyter och plasmaceller, samt adulta nematoder, larver och ägg. Degenerativa förändringar, som nådde in till epi- och perineurium, påvisades i perifera nervers rötter. I ett fall nådde den inflammatoriska processen in i ischiadicusnervens endoneurium och i ett annat fall in i ett ganglion. Dessutom sågs fall med mild glios i storhjärnan. Det inflammatoriska svaret gentemot parasiten var främst riktat mot äggen. I lucker bindväv intill nervvävnad i centrala nervsystemet påvisades larver i anslutning till ägg och rester av kläckta ägg, vilket indikerar att ägg kläckes där.

Denna undersökning visar att naturliga infektioner med Elaphostrongylus sp. förekommer hos vild älg och kan förorsaka patologiska förändringar i stora perifera nerver och centrala nervsystemet.

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