# A COMPARATIVE STUDY ON THE EFFICACY OF FOUR ANTHELMINTICS ON SOME IMPORTANT REINDEER PARASITES

En jämförande studie av effekten av fyra anthelmintika mot några betydelsefulla parasiter hos ren.

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*Abstract:* Four anthelmintic preparations were tested against some of the most important parasites of reindeer, i.e. warble fly (*Oedemagena tarandi*), nostril fly (*Cephenomyia trompe*), brainworm (*Elaphostrongylus rangiferi*), and lungworm (*Dictyocaulus viviparus*). Their efficacy against intestinal nematodes was also registered. Test drugs were Fenthion (Bayer), Fenbendazole (Hoechst), Mebendazole (Janssen), and Ivermectin (Merk Sharp & Dohme).

Against *O. tarandi* and *C. trompe* Ivermectin was 100% effective and Fenthion 86 and 100% respectively. The efficacy of Fen- and Mebendazole against these parasites was not significant.

Against *E. rangiferi* the benzimidazole compounds were highly effective, with Mebendazole a bit ahead. Ivermectin had a moderate effect and Fenthion had no effect on this parasite.

Against *D. viviparus* Fenbendazole, Mebendazole and Ivermectin were of equal, moderate-high effectiveness. No drug had a complete effect on the «arrested» larvae of *D. viviparus*. Fenthion had no effect at all.

Fenbendazole and Ivermectin were both 100% effective against intestinal nematodes. Mebendazole was less effective and Fenthion had no effects.

Ivermectin is considered to be the overall most effective anthelmintic in this test.

Key words: Reindeer, deworming, *Oedemagena tarandi, Cephenomyia trompe, Elaphostrongylus rangiferi, Dictyocaulus viviparus,* gastrointestinal nematodes.

***Rangifer** 3 (2):19—38*

NORDKVIST, M., REHBINDER, C., CHRISTENSSON, D., RÖNNBÄCK, C. 1983. En jämförande studie av effekten av fyra anthelmintika mot några betydelsesfulla parasiter hos ren.

*Sammandrag:* Fyra antiparasitmedel har prövats mot några av renens viktigaste parasiter, nämligen hudkorm (*Oedemagena tarandi*), svalgkorm (*Cephenomyia trompe*), hjärnmask (*Elaphostrongylus rangiferi*) och lungmask (*Dictyocaulus viviparus*). Vidare har medlens effekt på mag- tarmnematoder (Trichostongylider) också noterats. De prövade medicinerna var Fenthion (Bayer), Mebendazole (Leo/Janssen), Fenbendazole (Hoechst) och Ivermectin (Merck Sharp & Dohme).

Mot hud- och svalgkorm var Ivermectin 100% effektivt medan för Fenthion effekten var 86 resp 100%. Effekten av Fen- och Mebendazole mot de båda parasiterna var inte signifikant.

Mot hjärnmask noterades mycket hög effekt av Mebendazole och även Fenbendazole medan Ivermectin hade något sämre effekt med den valda doseringen. Fenthion hade ingen effekt på denna parasit.

Mot lungmask visade Fenbendazole och Ivermectin god effekt medan Mebendazole visade något lägre effekt. Inget av preparaten hade dock fullgod verkan på de vilande inaktiva 5:te stadiets larverna av denna parasit. Fenthion hade ingen effekt.

Mot mag-tarmnematoder var Fenbendazole och Ivermectin 100% effektiva medan Mebendazole hade en något lägre, delvis undertryckande effekt. Fenthion hade ingen effekt.

Ivermectin får anses vara det allmänt sett effektivaste maskmedlet i denna undersökning.

***Rangifer** 3 (2):19—38*

NORDKVIST, M., REHBINDER, C., CHRISTENSSON, D., RÖNNBÄCK, C. 1983. Vertaileva tutkielma neljän loislääkeaineen vaikutuksesta muutamia tärkeitä porojen loisia vastaan.

*Yhteenveto:* On kokeiltu neljää loislääkeainetta muutamia porojen tärkeinpiä loisia vastaan, nimittäin kurmua (*Oedemagena tarandi*), saulakkaa (*Cephenomyia trompe*), aivomatoa (*Elaphostrongylus rangiferi*) ja keuhkomatoa (*Dictyocaulus viviparus*). Edelleen on lääkeaineiden vaikutus maha- ja suolistomatoihin (Trichostrongyliidit) myöskin pantu merkille. Kokeillut lääkeaineet olivat Fenthion (Bayer), Mebendazole (Leo/Janssen), Fenbendazole (Hoechst) ja Ivermectin (Merck - Sharp and Dohme).

Kurmua ja saulakkaa vastaan oli Ivermectin 100% tehokas, kun taas Fenthionin vaikutus oli toisessa 86 ja toisessa 100%. Fen- ja Mebendazolen vaikutus molempia loisia vastaan ei ollut merkittävä.

Mebendazolen ja myös Fenbendazolen vaikutus aivomatoa vastaan havaittiin hyvin korkeaksi, kun taas Ivermectinillä oli jonkin verran huonompi vaikutus valitulla annostuksella. Fenthionilla ei ollut mitään vaikutusta tätä loista vastaan.

Keuhkomatoa vastaan osoitti Fenbendazole ja Ivermectin hyvän vaikutuksen, kun taas Mebendazolella oli jonkin verran heikompi vaikutus. Kuitenkaan ei millään lääkevalmisteista ollut täystehokasta vaikutusta tämän loisen lepääviin tehottomiin 5:asteen toukkiin. Fenthionilla ei ollut mitään vaikutusta.

Fenbendazole ja Ivermectin maha- ja suolistomatoja vastaan olivat 100% tehokkaita, kun taas Mebendazolella oli jonkin verran alhaisempi, osittain vaimentava vaikutus. Fenthionilla ei ollut mitään vaikutusta.

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## INTRODUCTION

The Swedish reindeer stock numbers about 260 000 heads, calves of the year uncounted. In Scandinavia there are some 700 000 reindeer altogether.

Roughly 90-95 per cent of the reindeer are infested with the larvae of *Oedemagena tarandi* L and *Cephenomyia trompe* L, annually causing an estimated loss to the reindeer industry of 5-15 per cent of the prduction income (Nordkvist 1980). The infestation rate of *Elaphostrongylus rangiferi* in reindeer is probably equally high as for the *Oestridae*. *Elaphostrongylus* is considered to be one of the major causes to losses, due to parasites, in the reindeer industry, (Roneus & Nordkvist 1962, Nordkvist et al. 1963, Bakken & Sparboe 1973, Kummeneje 1974, Rehbinder & Christensson 1977, Rehbinder et al. 1981). *Dictyocaulus viviparus* infection in reindeer has been reported by Skjenneberg (1968), Christensson & Rehbinder (1975), and Kummeneje (1977). Most reindeer are probably harbouring this parasite but the infestation seems to be especially serious in calves. The animals are infested in summer but clinical manifestations do not occur until next spring. This is probably due to inhibited larval development during winter which has been observed in other animals (Kummeneje 1977). The infestation rate of gastro-intestinal nematodes in reindeer is, as a rule, low - moderate (Christensson & Rehbinder 1975, Rehbinder & Christensson 1977) thus being of minor significance as far as animal health is concerned.

The aim of the present investigation was to study the effeicacy of four different anthelmintics on the above mentioned parasites.

## MATERIALS AND METHODS

### *Tested drugs*

- *Fenthion 50%* (Tiguvon® Bayer: 0.0 - dimenthyl (4 - methyl - thio - m - totyl) phosphorothioate). Tiguvon was administered by means of intramuscular injection, 1 ml Tiguvon/reindeer calf up to 50 kg bodyweight responding to 10 mg/kg bodyweight. Fenthion 50% has been routinely used against the larvae of *Oedemagena tarandi* and *Cephenomyia trompe* in reindeer (Nordkvist 1980). So far about 20 000 reindeer has been treated with this preparation in Sweden and even more so in Finland. Thus it has become an established anthelmintic against these parasites and its role in this study is mainly that of a comparison to the larvicidal efficacy of the other remedia tested.

- *Mebendazole* (Mebenvet® Janssen Pharmaceutica n. v.: Methyl (5 - benzoyl - 1 H - benzimidazol - 2 - yl) carbamate). Mebenvet powder containing 5% mebendazole, was administered, 6 mg mebendazol/kg bodyweight/day as a medicated feed for 10 days. Mebendazole has proved to be of high anthelmintic effeicacy against *Elaphostrongylus rangiferi* and gastrointestinal nematodes in reindeer at the same dosage/day, mixed in the feed through 10 days (Rehbinder et al. 1981).

- *Fenbendazole* (Axilur® Hoechst: Methyl - 5 -

Table 1. Groups of reindeer calves and bodyweights on day No. 0 (23/2), 15 (9/3), and 50 (13/4).
*Gruppindelning och kroppsvikter på försöksdag nr. 0 (23/2), 15 (9/3) och 50 (13/4).*

| Group I Controls | | | | | Group II Fenthion | | | | Group III Mebendazole | | | | Group IV Fenbendazole | | | | Group V Ivermectin | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Animal | sex | bodyweight | | | Animal | sex | bodyweight | | Animal | sex | bodyweight | | Animal | sex | bodyweight | | Animal | sex | bodyweight | |
| No | | 23/2 | 9/3 | 13/4 | No | | 23/2 | 9/3 | 13/4 | No | | 23/2 | 9/3 | 13/4 | No | | 23/2 | 9/3 | 13/4 |
| 53 | ♀ | 38 | 39 | 40 | 36 | ♀ | 42 | 44 | 46 | 54 | ♂ | 45 | 46 | 49 | 103 | ♂ | 51 | 54 | 56 | 118 | ♀ | 43 | 45 | 45 |
| 106 | ♂ | 49 | 51 | 52 | 40 | ♀ | 39 | 41 | 40 | 122 | ♂ | 36 | 34 | 39 | 138 | ♂ | 38 | 40 | 41 | 127 | ♂ | 44 | 46 | 49 |
| 123 | ♂ | 37 | 37 | 39 | 105 | ♂ | 46 | 47 | 51 | 157 | ♀ | 39 | 41 | 44 | 168 | ♀ | 31 | 32 | 34 | 170 | ♀ | 37 | 38 | 40 |
| 144 | ♂ | 46 | 46 | 49 | 146 | ♂ | 41 | 45 | 48 | 165 | ♀ | 32 | 33 | 34 | 172 | ♀ | 31 | 33 | 36 | 174 | ♀ | 40 | 41 | 43 |
| 145 | ♀ | 37 | 39 | 41 | 136 | ♀ | 37 | 37 | 40 | 167 | ♂ | 40 | 40 | 42 | 181 | ♂ | 36 | 40 | 44 | 182 | ♀ | 37 | 34 | 40 |
| 184 | ♀ | 37 | 38 | 37 | 155 | ♂ | 31 | 33 | 39 | 169 | ♀ | 30 | 30 | 31 | 186 | ♀ | 36 | 37 | 37 | 185 | ♂ | 37 | 40 | 45 |

(phenyl - thio) - benzimidazol - 2 - carbamate). A powder containing 4% fenbendazole was administered 6 mg fenbendazole/kg body weight /day as medicated feed for 10 days. The anthelmintic activity of Fenbendazole has so far not been tested in reindeer but has proved to be of high potency against gastrointestinal nematodes and tapeworm (sheep) in cattle, sheep, goats, horses and swine (Forstner & Hasslinger 1974, Enigk et. al. 1974, Ross 1975, Todd et al. 1976). It has also been used as an anthelmintic in wild ruminants (Böckeler & Segebade, 1977). In a controlled anthelmintic trial in deer Mackintosh & Mason (1983) found 85% and 99.7% drug efficiency of Febantel (belongs to the benzimidazole family) against immature and adult lungworms, respectively.

- *Ivermectin* MSD (Ivomec ® 1%, Merck-Sharp & Dohme: 22.23 - dihydroavermectin B1a + 22.23 - dihydroavermectin B1b). Ivomec was injected subcutaneoulsy 1 ml/50 kg bodyweight. The avermectins are macrocyclic lactones produced from fermentation broths of *Streptomyces avermitilis*. Some of these substances have recently been reported to be potent, broad-spectrum anthelmintic agents (Burg et al. 1979, Egerton et al. 1979). A chemical derivative, avermectin $B^1$, has been developed for commercial use (Ivermectin MSD) and proved to be highly effective against internal and external parasites in cattle, sheep, horses, swine and chickens (Egerton et al. 1979, Benz & Ernst 1981, Barth & Sutherland 1980, Drummond 1980). In the above mentioned controlled trial by Mackintosh & Mason (1983) Ivermectin was 100% effective against immature as well as adult lungworms in deer.

On nematodes and arthropods Ivermectin acts by disturbing the GABA neurotransmitting system. On flukes and tapeworms, which apparently do not use GABA as a neurotransmitter, Ivermectin has no effect. The GABA systems of mammals are confined in the central nervous system where Ivermectin cannot reach. This is apparently the reason for the wide safety margin in the host animals (30 x terapeutic dose).

The overall terapeutic dose in cattle and sheep is found to be 200 mcg Ivermectin/kg bodyweight subcutaneously injected (Armour et. al. 1980).

## *Test animals*

Out of a flock of 100 woodland reindeer calves 37 animals, shedding larvae of Elaphostrongylus rangiferi in the faeces, were selected for the

experiment. This flock, consisting of 20 male and 17 female calves, was divided as to bodyweight in 2 replicates, the heaviest and the lightest, respectively. From these two replicates 5 groups of 6 calves (3 from each replicate) were formed at random. The groups were then randomly assigned to the four drugs to be tested and the untreated control group. (Table 1).

The calves were weighed immediately before treatment and on days nos. 15 and 50 post treatment (Table 1). The weighings were done by means of a Salter spring balance.

During the ten days of treatment the two groups administered Fenbendazole and Mebendazole were isolated in separate pens. The food consumption was controlled twice daily.

After the treating period all the animals of the five groups were kept together in one big pen.

The animals were given a feed mixture at an estimated average rate of 1.5 kg per animal and day plus a fine-stemmed hay ad lib. Snow of a depth of about 50 cm covered the ground and served as water resource.

On the 50th day of the experiment the reindeer were slaughtered and a complete post-mortem examination of each animal was carried out.

### *Parasitological examination*

The principal organisms investigated were *Oedemagena tarandi, Cephenomyia trompe, Elaphostrongylus rangiferi, Dictyocaulus viviparus,* and gastrointestinal nematodes.

Larvae of the two *Oestridae* species were counted at slaughter. As far as *Oedemagena* was concerned each animal served as its own control as, due to the late-in-season treatment, it was possible to separate live larvae from dead ones. The efficacy on *Cephenomyia* was calculated from the average number of larvae of each group compared to that of the controls.

Faecal examination was made from stool samples from each animal. Samples were collected the day before dosing the animals and on the 15th day and 50th day after treatment (DAT). The samples were sent by mail to the laboratory and examined within 2 days.

The samples were examined with the following standard parasitological methods:

1. The McMaster technique (Soulsby, 1982) was used for counting eggs of gastrointestinal nematodes (epg).
2. A modified acid-ether technique (Coles, 1974) (acetic acid, ether and centrifugation at 1,500 rpm for 10 min) was used for the detection of larvae of *E. rangferi.* The amount of larvae was estimated on a 0 to +++ scale.
3. A Baerman apparatus (Coles, 1974) was used to recover the larvae of *D. viviparus.* The amount of larvae was estimated on a 0 to +++ scale.

After slaughter the lungs, the abomasa and the small and large intestines were brought to the laboratory for examination of parasites.

The lungs were cut open and the bronchi were examined for adult *D. viviparus* worms which were estimated on a 0 - +++ scale. The lungs were also examined for larvae of *E. rangiferi* by using a digestion technique described by Ronéus & Christensson (1979) and modified by Christensson as follows.

From lung tissue of the diaphragmatic lobe 100 g was sampled, cut into small pieces and further processed in a Stomacher for 5 min at 42°C. The digestion fluid has been described for other purposes by Thomsen (1977). The digested material was sieved through a 180 µ sieve into a separation funnel and kept there for 30 min. Of the sedimented material 15 ml was drawn and examined under a dissection microscope at 12x magnification.

The abomasum and first 10 m of the small intestine were cut open. The contents of each organ was washed through a 180 µ sieve. The remaindings in the sieve were collected and diluted to a final volume of 4 l. Of this material 1/10 was examined for parasites under a dissection microscope. The worms were specified and counted. The total stomach- and intestinal worm burden was then calculated. The large intenstines were cut open and examined for helminths, which were specified and counted.

### *Pathological examination*

At slaughter each animal underwent autopsy and all organs were macroscopically investigated except for abomasa and intestines (kept for parasitological investigations) and the spinal cord. Tissue samples from lung, liver, kidney, myocard and brain and macroscopically changed organs were fixed in 10% formal saline and sections stained with haematoxylinc-eosine. Lungs, heart, liver and kidneys were weighed, and their relative weights calculated.

Table 2. The efficacy of drugs tested against *Cephenomyia trompe* and *Oedemagena tarandi*. The reducing effect on number of larvae (%).

*De prövade medicinernas effekt på svalgkorm och hudkorm. Reducerande effekt på antalet larver (%).*

| Group | Cephenomyia trompe | | | Oedemagena tarandi | | | |
|---|---|---|---|---|---|---|---|
| | No. of animals | No. of larvae $\bar{x} \pm SE$ | Red. eff. vs controls % | Total No. of larvae $\bar{x} \pm SE$ | No. of dead larvae $\bar{x} \pm SE$ | Red. eff. % dead of Tot $\bar{x} \pm SE$ | Sign. of diff. to controls t-value |
| I Control | 6 | 20.2 ± 4.6 | - | 42.8 ± 13.1 | 0.5 ± 0.3 | 1.8 ± 1.3 | - |
| II Fenthion | 6 | 0 | 100 | 44.2 ± 10.3 | 36.8 ± 8.3 | 86.1 ± 4.7 | 17.3*** |
| III Mebendazole | 6 | 9.3 ± 3.0 | 61.2 | 43.7 ± 12.3 | 2.7 ± 1.5 | 16.3 ± 12.2 | 2.0[0] |
| IV Fenbendazole | 6 | 10.0 ± 5.2 | 58.7 | 52.5 ± 15.7 | 1.0 ± 0.4 | 3.0 ± 1.5 | 1.5[0] |
| V Ivermectin | 6 | 0 | 100 | 70.5 ± 20.6 | 70.5 ± 20.6 | 100 | *** |

### *Statistical methods*

The efficacy on nematodes of the anthelmintics used was calculated according to the method for controlled tests by Moskey and Harwood (1941).

The significance of differences between mean values was estimated by means of Student's t-test.

Student's t-test has also been used in estimating the significance of whether or not the difference between weights at two occasions differs from zero.

## RESULTS

### *Parasitological examination*

The results of different treatments on *C. trompe* and *O. tarandi* are shown in Table 2. The control animals had a rather low average number of larvae of each species. Fenthion had 100% reducing effect on *C. trompe* and 86% on *O. tarandi.* The two benzimidazole compounds were equally effective around (60%) against *C. trompe* and against *O. tarandi* the effect was 3-16%. Ivermectin was 100% effective against both species.

Table 3 shows the number of gastro-intestinal trichostrongylids and of adult worms and larvae of *E. rangiferi* and *D. viviparus* found per group at slaughter by ordinary parasitological methods, described above.

The results of the fecal examinations of the control animals (Table 4) showed an increase in the number of trichostrongylid eggs and of eggs and larvae of *Dictyocaulus viviparus* during late winter (March-April) when the investigation was conducted.

*Fenthion* (Table 3) had only 58% efficacy against trichostrongylids and no effect against *Nematodirus, Dictyocaulus* or larvae of *Elaphostrongylus.*

*Mebendazole* (Table 3) had a 91% efficacy against trichostrongylids and 95% against *Nematodirus* and 100% efficacy against larvae of *Elaphostrongylus.* However, 5 animals were infected with *trichostrongylids* and all were shedding parasite eggs (Table 6). The shedding had been totally inhibited 14 days after deworming but was then retained within another month. Shedding of larvae of *Elaphostrongylus* was shown on day no 15 but not 50 days after deworming. The efficacy against *Dictyocaulus* was only 42% and 3 animal were also shedding larvae.

*Fenbendazole* (Table 3) had a 100% efficacy against trichostrongylids and *Elaphostrongylus* larvae. The efficacy against *Dictyocaulus* was 92%, one animal remaining infected. There was no shedding of any

Table 3. Parasitological findings in groups/number of animals infected at autopsy 50 days after deworming.
*Parasitologiska fynd i grupperna/antalet infekterade renar vid obduktion 50 dagar efter avmaskning.*

| Groups | Total amount of | | | Total sum of |
|---|---|---|---|---|
| | Tricho-strongylids | Nematodirus spp | larvae of E. rang./ 100 g of lung tissue | estimates of D. viviparus |
| I Control | 21080/5 | 1540/2 | 9928/6 | 12/5 |
| II Fenthion | 8940/5 | 2040/5 | 10900/6 | 11/4 |
| III Mebendazole | 1960/5 | 80/1 | 0/0 | 9/3 |
| IV Fenbendazole | 0/0 | 0/0 | 0/0 | 1/1 |
| V Ivermectin | 0/0 | 0/0 | 581/5 | 0/0 |

parasite ova or larvae after deworming (Table 7).

*Ivermectin* (Table 3) had a 100% efficacy against trichostrongylids and *Dictyocaulus*. The reduction of larvae of *Elaphostrongylus* was 94%. However, 5 of 6 animals were still infected at autopsy and 2 were shedding larvae in their faeces (Table 8).

In all groups of reindeer occasional singular findings of eggs, worms and oocysts of *Capillaria sp*, *Moniezia sp* and *Eimeria spp*, were made at fecal examination and at autopsy.

## Pathological examination

### Brain

*Controls (group I)*

Macroscopically vital *E. rangiferi* worms were found in the leptomeninges of 3 animals (nos. 53, 144, 145). In one animal (no. 184) haemorrhagic streaks were noted in the lepto-meninges.

Microscopically all animals showed mild to moderate gliosis and also a mild to moderate infiltration of lymphocytes in the lepto-meninges, mainly around vessels. Focal infiltrates by eosinophils, diffuse or as cuffs around vessels, were also noted.

Where vital *E. rangiferi* were sectioned in the lepto-meninges only mild haemorrhages were found around the worm, while in the surrounding tissues was noted varying degrees of infiltrates of lymphocytes but also occasional eosinophils. In one animal (no. 145) infiltrates of eosinophils around vessels were found, and in connection with these, areas of focal demyelinization.

*Fenthion (group II)*

Macroscopically all animals appeared normal.

Microscopically 2 animals (nos 54, 169) were without changes while the remaining 4 animals showed mild gliosis and minor focal aggregates of lymphocytes in the meninges.

*Mebendazole (group III)*

Macroscopically 5 animals appeared normal while

Table 4. Parasite eggs and larvae found at fecal examination per group of 6 reindeer. *Control-group.*
*Ägg och larver av parasiter påvisade vid träckprovsundersökning.* Kontrollgrupp.

| Parasite | Time of faeces sampling | | | |
|---|---|---|---|---|
| | 1 month before treatment | Day of treatment | 15 days after treatment | 50 days after treatment |
| 1. Trichostrongylidae | | | | |
| Epg total | 400 | 800 | 900 | 1 900 |
| No. infected | 4 | 5 | 6 | 6 |
| 2. Elaphostrongylus larvae | | | | |
| Total estimate | 19 | 16 | 18 | 19 |
| No. infected | 6 | 4 | 6 | 5 |
| 3. Dictyocaulus larvae | | | | |
| Total estimate | 0 | 0 | 2 | 9 |
| No. infected | 0 | 0 | 1 | 4 |

Table 5. Parasite eggs and larvae found at fecal examination per group of 6 reindeer. *Fenthion-group.*
*Ägg och larver av parasiter påvisade vid träckprovsundersökning.* Fenthion-grupp.

| Parasite | Time of faeces sampling | | | |
|---|---|---|---|---|
| | 1 month before treatment | Day of treatment | 15 days after treatment | 50 days after treatment |
| 1. Trichostrongylidae | | | | |
| Epg total | 200 | 900 | 1 100 | 2 900 |
| No. infected | 2 | 6 | 6 | 6 |
| 2. Elaphostrongylus larvae | | | | |
| Total estimate | 21 | 21 | 20 | 23 |
| No. infected | 6 | 6 | 5 | 6 |
| 3. Dictyocaulus larvae | | | | |
| Total estimate | 0 | 0 | 3 | 12 |
| No. infected | 0 | 0 | 1 | 5 |

in animal no. 138 several cauliflower like nodules ranging from 1x1x1 mm to 3x1x20 mm were found in the meninges.

Microscopically these nodules were similar to those described for animals of group IV with the remnants of a dead nematode in the centre.

Animals nos. 103, 138, 168 and 181 also presented mild gliosis and mild infiltrates of lymphocytes, mostly focal around vessels, in the brain and lepto-meninges.

*Fenbendazole (group IV)*
Macroscopically 3 animals (nos 36, 40, 105) had grain- to peasized, cauliflower-like nodules in the meninges (Fig 1). In addition av vital *E. rangiferi* was found in the subdural space of animal no 105.

In one animal (no. 136) the dura had a focal area of greenish discoloration.

Microscopically the nodules were found to be granulomas composed of a rather dense connective tissue, (infiltrated mainly by lymphocytes), in the centre of which was present the remnants of a decomposed nematode surrounded by eosinophilic detritus masses, giant cells and eosinophils (Fig 2 & 3). Animal no 136 had a mild connective tissue proliferation in the *Dura mater* combined with a mild infiltration of eosinophils. One animal (no 155) did not show any lesions while the other 5 animals revealed a mild perivascular cuffing of lymphycytes in the brain tissues and lepto-meninges. In addition animal no 136 had small focal areas

Table 6. Parasite eggs and larvae found at fecal examination per group of 6 reindeer. *Mebendazole-group.*
*Ägg och larver av parasiter påvisade vid träckprovsundersökning.* Mebendazol-grupp.

| Parasite | Time of faeces sampling | | | |
|---|---|---|---|---|
| | 1 month before treatment | Day of treatment | 15 days after treatment | 50 days after treatment |
| 1. Trichostrongylidae | | | | |
| Epg total | 200 | 500 | 0 | 1 400 |
| No. infected | 2 | 4 | 0 | 5 |
| 2. Elaphostrongylus larvae | | | | |
| Total estimate | 22 | 10 | 3 | 0 |
| No. infected | 6 | 3 | 2 | 0 |
| 3. Dictyocaulus larvae | | | | |
| Total estimate | 0 | 0 | 0 | 7 |
| No. infected | 0 | 0 | 0 | 3 |

Table 7. Parasite eggs and larvae found at fecal examination per group of 6 reindeer. *Fenbendazole-group.*
*Ägg och larver av parasiter påvisade vid träckprovsundersökning.* Fenbendazol-grupp.

| Parasite | Time of faeces sampling | | | |
|---|---|---|---|---|
| | 1 month before treatment | Day of treatment | 15 days after treatment | 50 days after treatment |
| 1. Trichostrongylidae | | | | |
| Epg total | 400 | 500 | 0 | 0 |
| No. infected | 4 | 5 | 0 | 0 |
| 2. Elaphostrongylus larvae | | | | |
| Total estimate | 22 | 17 | 0 | 0 |
| No. infected | 6 | 6 | 0 | 0 |
| 3. Dictyocaulus larvae | | | | |
| Total estimate | 0 | 0 | 0 | 0 |
| No. infected | 0 | 0 | 0 | 0 |

of demyelimzation in the brain in connection with a mild proliferation of liacells.

*Ivermectin (groups V)*
Macroscopically all animals appeared normal.

Microscopically 2 animals (nos. 118 and 182) were normal. The remaining 4 had moderate to mild infiltrates of lymphocytes, mostly focal around vessels, in the brain and lepto-meninges.

Lungs
*Controls (Group I)*
Macroscopically all lungs presented pea- to walnut-sized nodular lesions in the parenchyma. The nodules were firm with a reddish-greenish cut surface. In addition, 3 of the animals (nos. 144, 145, 184) revealed large, deep red areas of consolidation of the anterior parts of the diaphragmatic, apical, and cardiac lobes.

Microscopically all lungs showed a broadening of the interstitium and focal aggregates of lymphocytes and eosinophils, but also large centrally necrotized areas, characterized by eosinophilic detritus masses surrounded by giant cells, eosinophils, and mononuclear cells, mainly lymphocytes. Varying degrees of a rather diffuse perivascular and periobronchial cuffing by lymphocytes and some plasma cells was present in all lungs. In four animals larvae of *E. rangiferi* were found. They were located in granulomas but also outside granulomas in normal appearing alveoli or alveoli revealing a minor reaction characterized by alveolar cell proliferation. Areas with eggs and larvae of *D. viviparus* were present in all lungs and revealed a marked tissue response, characterized by a strong proliferation of alveolar cells and intersititial connective tissue and a diffuse

Table 8. Parasite eggs and larvae found at fecal examination per group of 6 reindeer. *Ivermectin-group.*
*Ägg och larver av parasiter påvisade vid träckprovsundersökning.* Ivermectin-grupp.

| Parasite | Time of faeces sampling | | | |
|---|---|---|---|---|
| | 1 month before treatment | Day of treatment | 15 days after treatment | 50 days after treatment |
| 1. Trichostrongylidae | | | | |
| Epg total | 400 | 900 | 0 | 0 |
| No. infected | 4 | 6 | 0 | 0 |
| 2. Elaphostrongylus larvae | | | | |
| Total estimate | 25 | 17 | 3 | 3 |
| No. infected | 6 | 5 | 3 | 2 |
| 3. Dictyocaulus larvae | | | | |
| Total estimate | 0 | 0 | 1 | 0 |
| No. infected | 0 | 0 | 1 | 0 |

Fig. 1. Brain cavity of reindeer no. 188 (treated with Mebendazole). Note the cauliflower like granuloma in the dura (arrow).

*Fig 1. Hjärnskålen hos ren nr 188 (behandlad med Mebencazol). Ovservera det blomkålsliknande granulomet på insidan av hårda hjärnhinnan (pilen).*

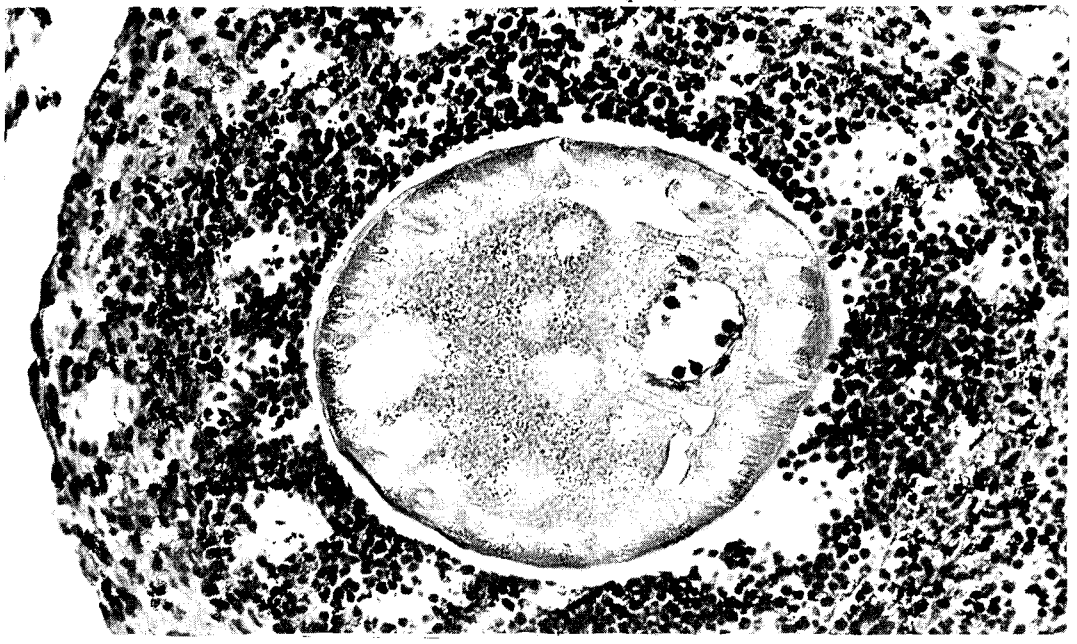

Fig. 2. Adult nematode in the centre of a cauliflower like granuloma. Note aggregation of lymphocytes and neutrophils around the nematode. Reindeer no. 105 treated with Fenbendazole. HE x 280.

*Fig 2. Tvärsnitt av vuxen mask i centrum av ett sådant granulom som visas på Fig 1. Observera ansamlingen av vita blodkroppar runt masken. Ren nr. 105 (behandlad med Fenbendazol). Förstoring 280 gånger.*

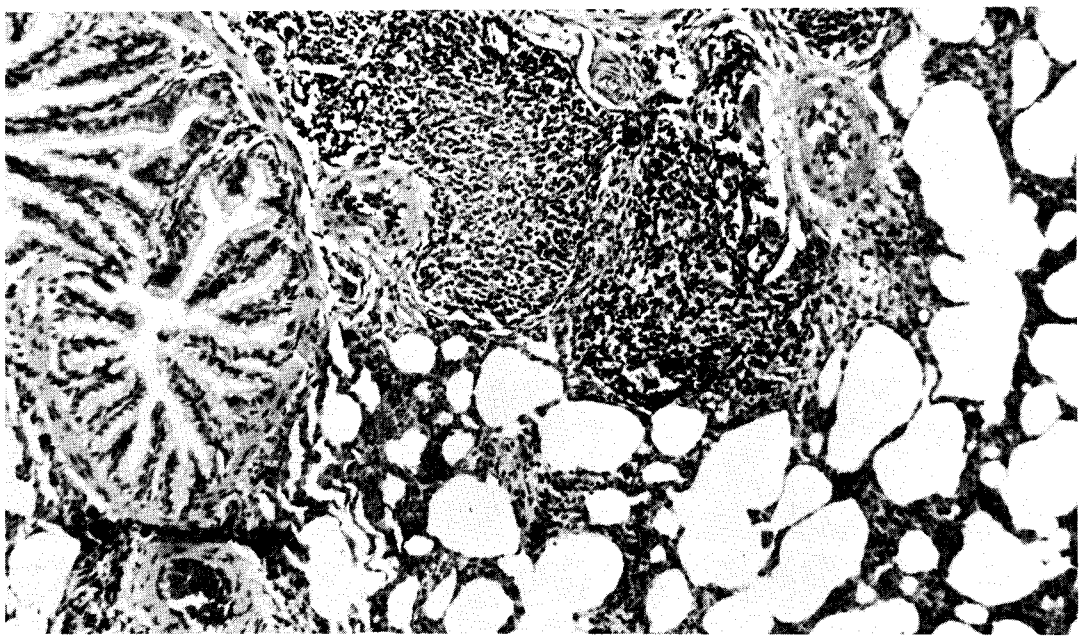

Fig. 3. Peribronchial and perivascular cuffings of lymphocytes. Note also broadened interstitium of alveolar walls. Animal no. 40 treated with Fenbendazole. HE x 110.

*Fig 3. Ansamling av vita blodkroppar runt bronker och kärl. Observera också lungblåsornas breddade väggar. Ren nr 40 (behandlad med Fenbendazol). Förstoring 110 gånger.*

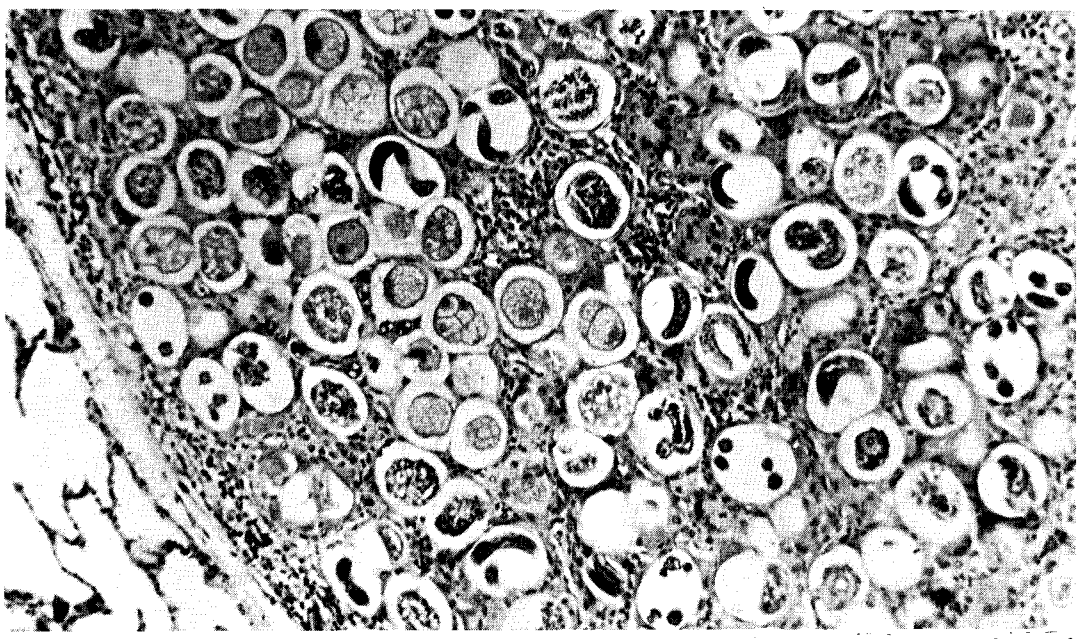

Fig. 4. Parasitic granuloma containing eggs of D. viviparus and larvae of *D. viviparus* and E. *rangiferi* in the lung of control animal no. 144. Note normal lung tissue outside the granuloma. HE x 110.

*Fig 4. Parasitgranulom innehållande ägg av lungmask och larver av både lung- och hjärnmask. Ren nr 144 (obehandlad). Förstoring 110 gånger.*

infiltration of lymphocytes and neutrophils (Fig 4).

In the bronchi numerous adult parasites and mucus mixed with neutrophils, eosinophils, lymphocytes, and eosinophilic detritus masses were seen.

The bronchial mucosa showed various degrees of infiltrates of lymphocytes, eosinophils and neutrophils but also a marked increase of goblet cells.

The consolidated areas had the characteristics of an alveolar cell pneumonia with heavy infiltrates of mainly lymphocytes. In these areas numerous eggs of *D. viviparus* were found.

*Fenthion (Group II)*

Macroscopially the lungs presented almost the same picture as those of the controls, but the lesions were much more extensive and severe. All lungs contained numerous *D. viviparus*.

Microscopically the lesions were very similar to those of the controls but much more pronounced. Heavy deposites of eggs and larvae were found in many parts of the lungs. Perivascular and peribronchial cuffing were almost absent but for diffuse infiltrates of lymphocytes.

*Mebendazole (Group III)*

In 3 animals (nos. 138, 168, 172) only some few pea-sized nodules in the parenchyma were found while in 2 animals (nos. 103, 186) no nodules were found but minor consolidated areas in the cardiac and apical lobes. In animal no 186 was also found a moderate amount of adult *D. viviparus*. Animal no 181 had a few nodules in the parenchyma and a minor consolidated area (2x2x2 cm) in the diaphragmatic lobe.

Microscopically the picture was less varied. All lungs presented areas with broadened interstitium and relatively marked peribronchial and perivascular cuffing. All lungs had granulomas surrounding dead parasites. These granulomas, however, varied markedly in size and were in two animals (nos. 103, 186) large and confluent. In animal no. 168 few eggs were detected whereas in animal no. 186 numerous eggs were present and also a markedly strong alveolar cell proliferation and infiltrates of eosinophils and lympthocytes. Adult *D. viviparus* were found on the bronchi and bronchioli. The number of larvae found was less than 1% of the number of eggs.

*Fenbendazole (Group IV)*

Macroscopically a few pea-sized nodules were found in the lung parenchyma of all the animals. One animal (no. 155) had minor dark areas of consolidation in the apical lobes.

Microscopically all animals presented areas with emphysema and areas with a markedly broadened interstitium, due to an increase of connective tissue, but with an alveolar epithelium that appeared normal. In all lungs focal areas were found with eosinophilic detritus masses in the centre, surrounded by giant cells and connective tissue, infiltrated mainly by lymphocytes. Pronounced perivascular and peribronchial cuffing with a well defined demarcation and appearing almost like lymph-nodes was evident in all but one animal (no. 36) which presented a more diffuse cuffing. The bronchi revealed an increase of goblet cells and regularly contained mucus mixed with eosinophilic detritus masses, eosinophils, lymphocytes, and neutrophils.

In addition one animal (no. 105) exhibited focal areas of alveolar cell proliferation and infiltration of lymphocytes and eosinophils around eggs of *D. viviparus*.

*Ivermectin (Group V)*

Macroscopically the lungs from animals nos. 118 and 170 appeared normal while those of nos. 127 and 182 had some few pea-sized nodules and nos. 174 and 185 numerous nodules in the parenchyma.

Microscopically 3 animals (nos. 118, 170, 174) revealed a broadened interstitium but had normal alveolar cells. Scattered foci of lymphocytic infiltrates surrounding old granulomatous tissue and a rather diffuse perivascular and peribronchial cuffing were also present. In animal no. 170 a moderate amount of larvae of *E. rangiferi* was found. The tissue response towards the larvae seemed almost negligible.

The lungs of animals nos. 127, 182 and 185 all contained eggs and larvae of *D. viviparus* with a marked tissue response characterized by proliferation of alveolar cells and broadened interstitium as well as heavy infiltrates by lymphocytes and eosinophils.

The bronci appeared as those of the controls. These changes were most pronounced in animal no. 185 which had numerous adult worms in the bronchi, and least pronounced in animal no. 127. In animals nos. 127 and 182 very few larvae but numerous eggs were found while in animal no. 185, in addition to worms and eggs, also numerous larvae were present. Perivascular and peribronchial

cuffing was pronounced, appearing almost as lymph nodes.

In table 9 the findings at pathological examination of the lungs have been added to the parasitological examination concerning *E. rangiferi* and *D. viviparus*. Only presence or non-presence of vital larvae and of adults has been recorded in this table. As far as *E. rangiferi* is concerned the only positive animal was found in the Fenbendazole group. Regarding *D. viviparus* the pathological examination adds one positive control animal, two Fenthion, two Fenbendazole and three positive Ivermectin animals to the parasitological findings. Thus these two examination methods may complement each other.

All lungs of animals carrying moderate to rich amount of *D. viviparus* were significantly heavier (relative and absolute weight) than noninfected or mildly infected lungs (Table 12).

**Kidneys**

All groups presented similar lesions. Macroscopically pinpoint to grain-sized gray lesions were seen on the surfaces. On the cut surface these lesions were found to extend varyingly into the parenchyma often in a triangular shape.

Microscopically was seen focal proliferations of connective tissue infiltrated by, sometimes, numerous lymphocytes. In connection with these lesions sclerosis of glomeruli and degenerative changes of the tubular epithelium were found.

**Liver**

All groups presented similar lesions. Almost all animals revealed a moderate amount of greyish, patchy lesions in the capsule. Microscopically these lesions were found to be focal fibrous thickenings of the capsule. In all livers were also noted various amounts of mainly periportal but also intralobular focal infiltrates of lymphocytes. In 3 animals old parasitic granulomas similar to those caused by *Onchocerca tarsicola* (Rehbinder et. al., 1975) were found.

**Heart**

All animals appeared normal macro- and microscopically but for one animal which had an old parasitic cyst subendocardially in the left ventricle wall and one animal which had an old parasitic granuloma on the epicardium, most probably caused by a dead *Setaria* (Rehbinder et al., 1975).

### *Weighings and feed consumption*

The reindeer were weighed on day nos. 0 (23/2), 15 (9/3) and 50 (13/4) (Table 1). Most of them gained weight during the experiment. The weight of the 15th day of female calf no. 182 in Group V was probably wrongly recorded as too low (Table 1).

All feed given, medicated feed incl., was promptly consumed. Individual consumption was not recorded.

## DISCUSSION

### *Oedemagena tarandi (warble fly) and Cephenomyia trompe (nostril fly). Table 2.*

*O. tarandi* and *C. trompe* have been estimated to cause heavy losses to the reindeer industry. Famphur (Warbex, Am. Cyanam.) was earlier, and successfully, used to more than 30 000 reindeer (Nordkvist 1967, Erne & Nordkvist, 1970). Later on Fenthion combined an equal efficacy with a broader safety margin and a lower dosage (Nordkvist 1980).

In the present study Fenthion was 100% effective against *C. trompe* but only 86.1% effective against *O. tarandi*. As far as *C. trompe* is concerned the figure was in full accordance with previous results but regarding *O. tarandi* the result was lower than expected (Nordkvist, 1980). The reducing effect was, nevertheless, highly significant.

The two benzimidazole compounds were not expected to have any larvicidal effect. As shown in Table 2, however, both compounds appeared to have some but not a significant reducing effect on the number of *C. trompe* larvae. It could not be excluded that this effect, instead of being systemic, was a matter of direct drug/larvae contact as a consequence of peroral administration route. Against larvae of *O. tarandi* the reducing effect was negligible.

The efficacy of Ivermectin on larvae of *Oedemagena* and *Cephenomyia* species was for the first time tested in reindeer. Ivermectin was 100% effective against *C. trompe* as well as against *O. tarandi*. This is in full accordance with results obtained by Drummond (1980) on *Hypoderma lineatum* in cattle.

### *Elaphostrongylus rangiferi (brain worm). Table 3 - 9.*

*E. rangiferi* was first described in Scandinavian reindeer by Ronéus & Nordkvist (1962). A

contribution to its occurrence in Sweden was given by Nordkvist et al. (1963). *E. rangiferi* is widely spread throughout Scandinavia and USSR (Polyanskaya 1963, Wissler & Halvorsen 1976, Rehbinder et al. 1981).

The adult worms are found mainly in loose connective tissue as intermuscular fasciae but also rather commonly in the meninges. The first stage larvae are found in the lungs. According to Kummeneje (1974) migrating larvae are supposed to cause most of the damage to the CNS. The localization in intermuscular fasciae sometimes causes a greenish discoloration that may call for condemnation of parts of the carcass at meat inspection (Grøholt 1969).

Fenthion (Group II) did not have any apparent effect against larvae of *E. rangiferi.* (Tables 9 and 13).

Mebendazole was found by Rehbinder et al. (1981) to be very efficient against larvae of *E. rangiferi.* They also reported that a few animals were still shedding larvae at the 10th DAT but not at the 40th DAT. The explanation for this was supposed to be the fact that some of the animals were submedicated due to low social ranking. Exactly the same pattern was observed in the present study although the social ranks of animals shedding larvae were not recorded (Tables 9 and 13). Mebendazole (Group III) has confirmed its efficacy (100%) against *E. rangiferi* as shown in Tables 3 and 9.

Fenbendazole (Group IV), being a member of the same benzimidazole family, acted similarly, but these animals did not shed any larvae at the 15th DAT. At the 50th DAT all animals of Group III and IV were free of *E. rangiferi* larvae in the faeces and in the lungs. At gross-pathological examination, however, one living adult worm was found on the brain of one animal in Group IV but none in Group III.

Cauliflower-like granulomas with remnants of a nematode in the centre were found in the meninges of some animals of both the benzimidazole groups. This kind of lesions in the leptomeninges caused by dead nematodes (in this case with great certainty *E. rangiferi*) has so far not been described, most probably due to the fact that until now there have not been drugs of equal efficacy against *E. rangiferi* available and for that reason adult worms have not been seen killed *in situ.* Granulomas, histologically similar, although much smaller and located in the cervical, thoracic and sacral regions of the spinal cord and on the spinal roots of the sciatic nerves, however, have been described earlier by Ronéus & Nordkvist (1962), Bakken & Sparboe (1973), and Kummeneje (1974).

Ivermectin (Group V) did not have a comparable efficacy as three animals of this group were shedding larvae of *E. rangiferi* at the 15th DAT and two were still shedding at the day of autopsy. In five animals larvae were found in the lungs at parasitological examination (Table 9).

As mentioned above, the GABA neurotransmitting systems of mammals are confined behind the blood barrier of the CNS, where Ivermectin cannot reach. This fact might be the reason why some *E. rangiferi* worms, located in the CNS, remained unaffected by this compound.

### *Dictyocaulus viviparus (lungworm) Table 3 - 9.*

*D. viviparus* has been found in many wild ruminant species, for instance many of the Cervidae family. Nilsson (1971) found low level infections of *D. viviparus* in Swedish roedeer (*Capreolus capreolus*) and moose (*Alces alces*). Corrigall et al (1980) demonstrated the presence of *D. viviparus* in farmed red deer (*Cervus elaphus*) in Scotland, and Mason (1983) states that *D. viviparus* is the most important parasite of farmed red deer in New Zealand. Gupta & Gibbs (1971) has described *D. viviparus* in American moose (*Alces americanus*) and Presidente et al. (1972) in elk (*Cervus canadensis nelsoni*). *D. viviparus* in reindeer has been reported by Christensson & Rehbinder (1975), Kummeneje (1977) and Rehbinder et al. (1981).

Like several other nematodes *D. viviparus* has the ability of inhibiting its growth at the larval stage of early $L^5$ (Michel 1955, Jørgensen 1981), so called arrested larvae. Animals carrying arrested larvae, silent carriers, are shedding neither eggs nor larvae. This phenomenon occurs mostly when the infestation is low, usually due to animal resistance. According to Jørgensen (1981) and others inhibited growth is the main way of overwintering of larvae and the main source of reinfection of pastures.

In reindeer Kummeneje (1977) and Rehbinder et al (1981) have described the presence and increase of *D. viviparus* larvae during March - April, interpreted as a result of regrowth of inhibited larvae.

In the present study the nonmedicated controls as well as the Fenthion group gave a very clear picture

Table 9. Comparison between the three methods used to elucidate the presence of *Elaphostrongylus rangiferi* and *Dictyocaulus viviparus*. Date of observation April 13. experimental Day No. 50.

*Jämförelse mellan de tre använda metoderna för bestämning av förekomst av hjärnmask och lungmask.*

| Group | Animal No. | Elaphostrongylus rangiferi | | | | Dictyocaulus viviparus | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Parasit exam | | Pathol exam | Tot | Parasit exam | | Pathol exam | Tot |
| | | faeces | lung | | | faeces | lung | | |
| I Control | 53 | + | + | + | + | - | + | + | + |
| | 106 | + | + | - | + | + | - | + | + |
| | 123 | + | + | - | + | + | + | + | + |
| | 144 | + | + | + | + | + | + | + | + |
| | 145 | + | + | + | + | + | + | + | + |
| | 184 | - | + | + | + | + | + | + | + |
| II Fenthion | 54 | + | + | - | + | - | + | + | + |
| | 122 | + | + | + | + | + | - | + | + |
| | 157 | + | + | + | + | + | + | + | + |
| | 165 | + | + | + | + | + | + | + | + |
| | 167 | + | + | + | + | - | - | + | + |
| | 169 | + | + | - | + | + | + | + | + |
| III Mebendazole | 103 | - | - | - | - | - | + | - | + |
| | 168 | - | - | - | - | - | - | - | - |
| | 168 | - | - | - | - | + | + | + | + |
| | 172 | - | - | - | - | + | - | + | + |
| | 181 | - | - | - | - | - | - | - | - |
| | 186 | - | - | - | - | - | + | + | + |
| IV Fenbendazole | 36 | - | - | - | - | - | - | - | - |
| | 40 | - | - | - | - | - | - | - | - |
| | 105 | - | - | + | + | - | - | + | + |
| | 146 | - | - | - | - | - | - | - | - |
| | 136 | - | - | - | - | - | + | - | + |
| | 155 | - | - | - | - | - | - | + | + |
| V Ivermectin | 118 | + | + | - | + | - | - | - | - |
| | 127 | - | + | - | + | - | - | + | + |
| | 170 | + | + | + | + | - | - | - | - |
| | 174 | - | - | - | - | - | - | - | - |
| | 182 | - | + | - | + | - | - | + | + |
| | 185 | - | + | - | + | - | - | + | + |
| | | 13 | 17 | 10 | 18 | 10 | 13 | 20 | 22 |

+ = positive
- = negative

of arrested larvae (Table 13). In late February There was no shedding of *D. viviparus* larvae, in mid March only a few larvae were detected but in mid April the shedding of larvae was fluorishing and adult worms, eggs and larvae were found in the lungs at autopsy.

Infected lungs were significantly heavier (rel weight) than noninfected or only lightly infected ones (Table 12). This was appartantly an effect of oedema and consolidation of lung tissue in affected animals.

The importance of *D. viviparus* to the reindeer industry should not be underestimated. The onset of growth of the arrested larvae happens to coincide with a period of the year when reindeer normally live on the verge of malnutrition. The findings of large areas of parasitic pneumonia in clinically healthy animals and the very significant

Table 10. Interaction on body weights, both sexes. (In all groups: 6 animals).

*Den relativa kroppstillväxten under försöket (%), båda könen.*

| Treatment | Rel. increase of body weight (per cent) (Mean ± SE.) Degree of significance vs «entrance weight» (t-values) | |
|---|---|---|
| | Interval 0 - 15 days | Interval 0 - 50 days |
| I Controls | 2.47 ± 0.89<br>t = 2.790* | 5.69 ± 1.41<br>t = 4.033** |
| II Fenthion | 0.82 ± 1.50<br>t = 0.54 | 7.44 ± 1.37<br>t = 5.438** |
| III Mebendazole | 5.79 ± 1.22<br>t = 4.747** | 11.42 ± 2.78<br>t = 4.110** |
| IV Fenbendazole | 4.71 ± 1.38<br>t = 3.407* | 11.79 ± 2.88<br>t = 4.092** |
| V Ivermectin | 2.40 ± 2.26<br>t = 1.063 | 10.23 ± 2.44<br>t = 4.193** |
| Ivermectin Corr.<br>(see text) | 4.72 ± 0.85<br>t = 5.546** | 11.30 ± 2.49<br>t = 4.538** |

Table 11. Interaction on body weight, during the interval of 0-50 days, females and males separately.

*Den relativa kroppstillväxten under hela försöksperioden, hon- och hankön åtskilda.*

| Treatment groups | Rel. increase of body weight (per cent) «Mean ± SE.) Degree of significance vs «entrance weight» (t-values) | | | |
|---|---|---|---|---|
| | Females | (n) | Males | (n) |
| I (Control) | 5.36 ± 3.12<br>t = 1.717 | (3) | 6.02 ± 0.32<br>t = 18.548** | (3) |
| II + IV + V | 7.72 ± 1.24<br>t = 6.217*** | (10) | 15.83 ± 2.39<br>t = 6.628*** | (8) |

*Note:*
*Weight increase for femlaes vs males*
*t = 3.012** (0.01 > p > 0.02)*

Table 12. Relative weights of lungs, infected vs non - or lightly infected with *D. viviparus* and *E rangiferi*. ($\bar{x}$ ± SE).

*Relativa lungvikter (% av kroppsvikten), infekterade, lätt infekterade och icke infekterade med lungmask och hjärnmask.*

| A infected | | B non-infected | | C lightly infected | |
|---|---|---|---|---|---|
| n | $\bar{x}$ SE | n | $\bar{x}$ SE | n | $\bar{x}$ SE |
| 15 | 2.35 ± 0.17 | 8 | 1.38 ± 0.06 | 7 | 1.49 ± 0.05 |

*A vs B t = 5.381****
*A vs C t = 4.853****
*B vs C t = 1.410*

Table 13. Parasitological examination of the presence of *Elaphostrongylus rangiferi* and *Dictyocaulus viviparus*.
*Parasitologisk undersökning av förekomsten av hjärnmask och lungmask.*

| Group | Animal No. | Elaphostrongylus rangiferi | | | | Dictyocaulus viviparus | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Faeces | | | Lungs | Faeces | | | Lungs |
| | | 23/2 | 9/3 | 13/4 | 13/4 | 23/2 | 9/3 | 13/4 | 13/4 |
| I Control | 53 | + | +++ | +++ | +++ | - | - | - | + |
| | 106 | ++ | ++ | ++ | ++ | - | - | +++ | - |
| | 123 | +++ | +++ | +++ | +++ | - | - | +++ | ++ |
| | 144 | ++ | +++ | +++ | + | - | + | + | + |
| | 145 | +++ | + | ++ | + | - | - | (+) | + (+) |
| | 184 | +++ | + | - | (+) | - | - | + | (+) |
| II Fenthion | 54 | + | - | ++ | + | - | ++ | - | ++ |
| | 122 | +++ | +++ | +++ | +++ | - | - | (+) | - |
| | 157 | ++ | ++ | ++ | +++ | - | - | ++ | ++ |
| | 165 | ++(+) | +++ | +++ | +++ | - | - | ++ | + |
| | 167 | +++ | +++ | +++ | +++ | - | - | - | - |
| | 169 | ++ | ++ | + | (+) | - | - | (+) | (+) |
| III Mebendazole | 103 | ++(+) | - | - | - | - | - | - | + |
| | 138 | + | - | - | - | - | - | - | - |
| | 168 | ++(+) | + | - | - | - | - | + | + |
| | 172 | + | - | - | - | - | - | + | - |
| | 181 | ++ | - | - | - | - | - | - | - |
| | 186 | +++ | (+) | - | - | - | - | - | +(+) |
| IV Fenbendazole | 36 | + | - | - | - | - | - | - | - |
| | 40 | + | - | - | - | - | - | - | - |
| | 105 | +++ | - | - | - | - | - | - | - |
| | 146 | ++ | - | - | - | - | - | - | - |
| | 136 | ++(+) | - | - | - | - | - | - | + |
| | 155 | ++ | - | - | - | - | - | - | - |
| V Ivermectin | 118 | ++ | - | + | + | - | - | - | - |
| | 127 | ++(+) | + | - | (+) | - | - | - | - |
| | 170 | ++(+) | (+) | + | + | - | (+) | - | - |
| | 174 | + | - | - | - | - | - | - | - |
| | 182 | + | - | - | (+) | - | - | - | - |
| | 185 | +++ | (+) | - | (+) | - | - | - | - |

increase of the relative weight of lungs infected with *D. viviparus* indicates that this parasite, especially in herds in a bad condition, may play an important role in disease outbreaks or contribute to losses interpreted as due to starvation. The experimental animals were all well fed, in fact almost everyone gained weight during the experimental period (Table 1). Nevertheless, several animals of the control and incompletely dewormed groups developed pronounced parasitic pneumonias. As mentioned above Fenthion had no or only a negligible effect on *D. viviparus*.

Considering all three evaluation methods used the efficacy of the two benzimidazole compounds could be characterized as pronounced and of equal potency (Table 9). An equal judgement could be passed on the efficacy of Ivermectin. The parasitological and pathological examination, however, did not coincide very well. At the parasitological examination no larvae were found in the faeces nor were any adult worms found in the lungs. At the histological examination, on the other hand, eggs and larvae in granulomas, and/or adult worms were observed in the bronchi in three treated animals.

As a matter of fact granulomas were present in the

Table 14. Calculated efficacy of four anthelmintics as related to control. Reducing effect (%) on number of worms or larvae found or estimated. Number injected animals of each group (parasitological and pathological examination).

*Beräknad effekt av de fyra maskmedlen. (parasitologisk och patologisk undersökning). Reducerande effekt (%) på det påvisade eller uppskattade antalet maskar eller larver. Antalet infekterade renar i varje grupp.*

| Anthelmintic | Trichostrongylids 1) | | Elaphostrongylus rangiferi | | Dictyocaulus viviparus | | Oedemagena tarandi | | Cephenomyia trompe | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Red. eff. % | No. inf. anim. | Red. eff. % | No. inf. anim. | Red. eff. % | No. inf. anim. | Red. eff. % | No. inf. anim. | Red. eff. % | No. inf. anim. |
| Controls | - | 6 | - | 6 | - | 6 | 2[4] | 6 | - | 6 |
| Fenthion | 29 | 6 | 0 | 6 | 8 | 5 | 86 | 6 | 100 | 0 |
| Mebendazole | 96 | 5 | 100 | 0 | 42 | 4 | 16 | 6 | 61 | 4 |
| Fenbendazole | 100 | 0 | 100[2] | 1[2] | 92 | 3 | 3 | 6 | 59 | 5 |
| Ivermectin | 100 | 0 | 94 | 5 | 100[3] | 3[3] | 100 | 0 | 100 | 0 |

*1) Nematodirus spp incl. 3) see under 2)*

*2) The discrepancy between these two figures is a consequence of using both parasitological and pathological methods.*

*4) «natural death rate».*

lungs of animals of all groups. For that reason it seems probable that neither of the three effective drugs (Fenbendazole, Mebendazole and Ivermectin) had a total larvicidal effect on pre-adults of *D. viviparus*. Some of the resting pre-adults probably do not, due to their confined location, come in contact with the drug, thereby getting an opportunity to mature into adult, egg producing worms. Eggs, above all, are supposed to cause local hypersensitivity reactions resulting in the formation of pronounced granulation tissue. These granulomas may have an influence on the excretion of larvae and, as a consequence, the result of the parasitological examination.

As far as *D. viviparus* is concerned Ivermectin, Fenbendazole and Mebendazole had a pronounced but not complete effect, probably due to less effect on pre-adults. As to the two benzimidazoles the result is in accordance with Mackintosh and Mason (1983) who reported a lower drug efficiency against pre-adult lungworms than against adults but regarding Ivermectin it is not, as this compound in their report was 100% effective against pre-adult as well as adult lungworms.

### *Gastrointestinal nematodes*

The gastrointestinal nematodes are, according to Christensson & Rehbinder (1975) and Rehbinder & v Szokolay (1978), usually not of any particular significance to reindeer. In the present study has, nevertheless, the effect of the four drugs on adult worms and non-arrested larvae in the lumen of the gastrointestinal tract been registered.

The original egg production of gastrointestinal parasites was moderate. There was, however, a distinct trend of increasing egg production in some of the groups, a springrise, for the first time documented in reindeer. This phenomenon was, of course, most obvious in the control group but also in the Fenthion and, to a less extent, in the Mebendazole groups. Fenbendazole and Ivermectin had an efficacy on gastro-intestinal worms of 100%. Mebendazole was 91% effective. This preparation had, however, a total but temporary effect on the eggproduction immediately after treatment. Reinfection seemed unlikely due to the facts that all groups were kept together in one pen and the ground was covered by half a meter of snow.

### *Weighings*

The reindeer were weighed three times during the experimental period; immediately before treatment, at the 15th DAT, and at the 50th DAT (Table

1). Table 10 shows that from 0 - 50 DAT all groups increased their body weights in a statistically significant way, probably a result of good feeding. There was at this interval no statistically significant difference of weight gain between groups.

When comparing groups it is to be considered that within groups the sex ratio was even 3/3 but for Group V (Ivermectin) within which the ratio was 2 ♂♂/4 ♀♀. As shown in Table 11 the average weight gain in males was significantly greater than in females. Correcting for this discrepancy of sex ratio by excluding the female no 182, the weight of which was probably misread at the 15th DAT, and adding a hypothetic male weighing the average weight of all males and gaining the average weight gain of all males the figures of the 50th DAT are only slightly influenced (Table 10). The figures of the 15th DAT, however, are changed on to a highly significant level, bringing the Groups III, IV and V closer together as far as body weight is concerned (Table 10).

Although there were no significant differences between groups at either of the two weighings but for one at the 5% probability level between groups II and III at the 15th DAT, there was an obvious difference of means between groups I and II on one side and III, IV and V on the other which most likely reflects the total effect of deworming, probably above all the disappearance of *D. viviparus*. This trend would probably have been more pronounced if the groups had been made larger and, of course, if the reindeer had been kept under natural grazing conditions.

The pattern of causes that could be vaguely seen behind the weight figures is mainly built up by following facts.

— The Fenthion group had a very poor weight development during the first 15 days, probably due to a subclinical toxic effect of the drug (Persen et al., 1982). Although the *C. trompe* larvae were completely destroyed and the *O. tarandi* larvae strongly reduced the weight gain of the group did not reach the level of the other treated groups at the end of the experiment. With all reservations this fact might be credited the effects of the other drugs on *D. viviparus*, *E. rangiferi*, and intestinal nematodes (in order of probable importance).

— During the last 35 days of the experiment the four treated groups increased their body weights at a very similar rate and they cannot statistically be separated from each other. Under natural grazing conditions, however, the development of body weights would probably have been more significantly related to the different drugs.

## CONCLUSIONS

In this study Ivermectin has come out as the most overall efficient anthelmintic. Against *E. rangiferi*, however, Fenbendazole and Mebendazole were superior to Ivermectin at recommended dosage (Table 14).

In practice, the broad anthelmintic spectrum and easy handling of Ivermectin seems to make this drug the best choice for routine deworming of reindeer.

If a heavy infestation of *E. rangiferi* has been established or is expected Ivermectin treatment might be combined with Mebendazole or Fenbendazole medication, if a feeding situation could be arranged. In such a case, of course, prophylactic measurements have to be taken as well.

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