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Moxidectin as an Endectocide in Reindeer

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Oksanen A, Nieminen M: Moxidectin as an endectocide in reindeer. Acta vet. scand. 1998, 39, 483-489. – During the winter 1991-92, 42 reindeer hinds of the Kaamanen Experimental Reindeer Herd in Finnish Lapland, naturally infected with various parasites, were allocated to 3 groups. One group was an untreated control group and the other 2 groups received either moxidectin or ivermectin at a dose of 200 μg kg^{-1} subcutaneously. The efficacy of treatment was followed with monthly faecal examinations for nematode eggs and counting of warbles, *Hypoderma tarandi* larvae, and throat bots, *Cephenemyia trompe* larvae, from live animals in spring. The efficacy of moxidectin against warbles (92.8%) and throat bots (70.8%) did not match that of ivermectin, which was 100% against both species. Both moxidectin and ivermectin were effective against gastrointestinal trichostrongylid egg production over the December to May trial period indicating good efficacy against adult and inhibited trichostrongylids. Only non-significant differences were seen in weight development and calf birth weights between the groups. Because of its only moderate insecticidal efficacy, moxidectin cannot be recommended as an endectocide in reindeer.

warbles; throat bots; Hypoderma tarandi; Cephenemyia trompe; trichostrongylids; ivermectin.

Introduction

Reindeer husbandry in northern Finland has used strategic antiparasitic treatment since the late 1970's. First organophosphates administered systemically were used to control warbles (*Hypoderma tarandi* larvae) and throat bots (*Cephenemyia trompe* larvae) and, since the early 1980's, ivermectin has been used (*Nieminen* 1989). Ivermectin is a synthetic derivative of abamectin, a natural avermectin produced by the actinomycete *Streptomyces avermitilis* (*Shoop et al.* 1995). Ivermectin has been shown to perform better than organophosphates against these parasites, as well as being efficacious against various nematodes (*Nordkvist et al.* 1983) and the pentastomid "sinus worm" *Linguatula arctica* (*Haugerud et al.* 1993). Moxidectin is not an avermectin but a member of the milbemycin group. It is synthetically derived from nemadectin, a natural macrocyclic lactone fermentation product of the actinomycete *Streptomyces cyaneogriseus* ssp. *noncyanogenus* (*Zulalian et al.* 1994). Its mode of action is probably similar to that of the avermectins (*Shoop et al.* 1995). The persistent efficacy of moxidectin was greater than that of ivermectin against ovine trichostrongylids (*Taylor et al.* 1993) and against induced *Dictyocaulus viviparus* and *Ostertagia ostertagi* infections in cattle (*Hubert et al.* 1995, *Barth et al.* 1997). Avermectins and milbemycins are called endectocides because of their broad spectrum efficacy against both endo- and ectoparasites (nematodes, insects and arachnids). Due to the high nematocidal potency of mox-

idectin, it appears to be a good candidate as an endectocide for use in reindeer as the treatments are done during winter, when nematode parasites of reindeer may be hypobiotic (*Nordkvist et al.* 1984). The aim of the present trial was to evaluate the commercial injection formulation (CYDECTIN® 1% vet inj, American Cyanamid, now Fort Dodge) of moxidectin in reindeer by comparing its antiparasitic efficacy with that of the standard treatment, injectable ivermectin. The differences in animal performance, measured as weight development in the treatment groups as well as the birth and autumn weights of calves born to the groups, were also investigated.

Materials and methods

The trial was initiated on 16 December, 1991, in the Kaamanen Experimental Reindeer Herd (69°09′ N, 27°00′ E) in northern Lapland. Forty-two adult reindeer hinds marked with individually numbered collars were weighed and allocated to 3 similar groups according to age. The treatment given to each group was drawn by lot. Group C was an untreated control group, group M animals were treated with moxidectin (CYDECTIN® 1% vet inj., Fort Dodge) at a dose of 200 μg kg^{-1} subcutaneously in front of the left shoulder, and Group I reindeer received ivermectin (IVOMEC® 10 mg/ml vet inj, MSD, now Merial) likewise at 200 μg kg^{-1}. Following treatment, the animals were observed hourly for adverse reactions during 12 h.

The herd was free-ranging in a fell and pine-birch forest area of 1400 hectares, and it was gathered for weighing and sampling monthly until May. When the animals were collected, faecal samples were taken from rectum. The samples were refrigerated and examined as soon as possible, mostly within 4 days after collection.

Faecal egg counts (FEC) were done according to a modified McMaster method using saturated NaCl solution with 200 g sucrose/litre, each egg counted representing 20 eggs per gram (epg). Nematode eggs were identified as trichostrongylid eggs if they were indistinguishable from those of the family Trichostrongylidae: oval or ellipsoid, not markedly asymmetrical, thin-shelled and length 60 to 100 μm, to the genus *Capillaria* if they were rough-shelled, dark-stained, of barrel shape, length about 50 μm, and with slightly protruding polar plugs, or to the genus *Skrjabinema* if they were typical to the genus: about 50 to 70 μm long, thin-shelled and markedly asymmetrical (like an orange section). For statistical treatment, all the trichostrongylid faecal egg count values from each individual from January to May were summed up and the sum was divided by the number of samples (5) to get an individual faecal egg count mean value (FECM).

Warbles were counted on May 12 by visual examination and digital palpation. When the amount of warbles exceeded 30, the count was done in tens, because adjacent warbles might blend together and prevent exact enumeration.

Throat bots were counted on May 12 endoscopically using a bronchoscope designed for humans (*Oksanen et al.* 1992b). The amount seen was estimated to the nearest 5 if it exceeded 25.

The hinds were weighed using an ovine balance modified to enable the weighing of reindeer (1 kg reading intervals). The new-born calves were weighed within 24 h of birth (spring balance, 100 g intervals). Calves were also weighed in autumn 1992 to elucidate the survival and growth.

Reductions in the respective parasite burden were calculated from the geometric means of parasite numbers in the treated groups compared to the control group, applying the World Association for the Advancement of Veterinary Parasitology (WAAVP) guidelines (*Wood et al.* 1995). The significance of difference in num-

bers of warbles and throat bots, as well as in FECMs between the groups was tested in Kruskal-Wallis one-way analysis of variance. Weight gain differences were statistically tested using the one-way analysis of variance. All statistical analyses were carried out with the Statistix 4.1 analytical software package (*Anon.* 1994).

Results

No adverse reactions could be noticed following either of the treatments. During the trial, one animal of the group M died due to a cause unrelated to the trial, and one animal of the group C disappeared leaving no trace. Trichostrongylid eggs were on December 16 (day 0) recorded in low numbers (max. 200 epg) from almost half of the animals in all the groups. The average trichostrongylid FEC remained positive in the control animals throughout the experimental period with peak values (~170 epg and ~90 epg) in March and May. After treatment the trichostrongylid FECs became negative in the groups M and I. Subsequently (mostly only after March) they increased at a much slower rate than those of the control group (Fig. 1). The FECMs were significantly different between the groups ($p<0.001$) (Table 1), with both the treatments causing >90% reduction.

Both moxidectin and ivermectin appeared to reduce *Capillaria* egg production, but the difference in the egg counts was not significant. The geometric mean of *Capillaria* egg counts also in the control group remained mostly below 2 epg. *Skrjabinema* eggs were seen in April and May in small numbers in the faeces of a few animals belonging to all of the groups.

In the control group, 12 hinds out of 13 harboured warbles (median intensity 50, range 8-120). Moxidectin clearly had efficacy against them (8 of 12 infected, median intensity 4, range 2-11). No warbles were found in any of the ivermectin treated animals. The difference in the number of warbles between the groups was statistically significant ($p<0.001$). In comparison of the mean warble ranks, group C differed ($p<0.05$) from groups M and I.

All 13 of the control group hinds harboured throat bots (median intensity 13, range 2-35). Nine of 12 moxidectin treated animals were infected (median intensity 5.5, range 1-15). No throat bots were found in any of the ivermectin treated animals. The difference in the number of throat bots between the groups was statistically significant ($p<0.001$); the mean throat bot rank of the I group differed from the other 2 groups.

The mean weight gain between day 0 and day 130 (April 24) was highest and the calf birth weight lowest in the untreated group, however, the difference between the groups was not significant (Table 2). One animal of the group C gained 17 kg and one of the group I lost 11 kg. These 2 animals had a large influence on the mean and s.e.m. for their respective groups.

Discussion

During the trial winter, trichostrongylid egg output differed from that experienced in other years in the same herd (*Oksanen et al* 1992a, 1993, *Oksanen* 1996) in that at the beginning of the trial in December many animals excreted eggs. The egg output of the untreated control group also never reached zero. In March, there was an astounding peak in trichostrongylid egg output of the control group (Fig. 1). There is no readily available good explanation for that.

Moxidectin has been found to be highly efficacious against the most important nematode parasites of cattle and sheep (*Ranjan et al* 1992, *Taylor et al.* 1993), as has ivermectin (*Campbell & Benz* 1984). In the present trial, both moxidectin and ivermectin showed high efficacy against trichostrongylids in reindeer.

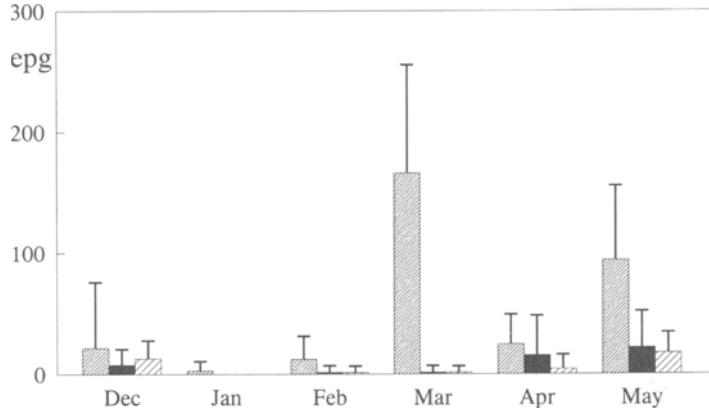

Figure 1. Mean (standard deviation of the mean) of trichostrongylid egg output of Kaamanen reindeer hinds of control and moxidectin and ivermectin treatment groups, sampled monthly from December 1991 to May 1992. ▨ Control, no treatment. ■ Moxidectin subcutaneously 200 μg kg^{-1} on December 16. ▨ Ivermectin subcutaneously 200 μg kg^{-1} on December 16.

Injectable moxidectin was in one trial 96% effective against first stage larvae of the ovine nasal bot fly *Oestrus ovis,* but the efficacy against second and third stage larvae was 100% (*Puccini et al.* 1994). At the time of treatment in the present trial, obviously all the *C. trompe* were 1st stage larvae (*Nilssen & Haugerud* 1995) and thus perhaps least susceptible to treatment, which might have contributed to the low (70.8%) efficacy.

Moxidectin has also been reported to have high efficacy against cattle warbles (*Scholl et al.* 1992, *Lonneux & Losson* 1994). In the present trial the efficacy of moxidectin injection against reindeer warbles was 92.8%, which is at the same level as the efficacy of the organophosphate fenthion (*Nordkvist et al.* 1983). This efficacy might be considered substantial. However, as ivermectin in the present trial, and also in many other experiments (*Nordkvist et al.* 1983, *Oksanen et al.* 1992a, 1993, *Oksanen* 1996) killed 100% of warbles, moxidectin is definitely not the first choice endectocide. In two trials with horses, oral moxidectin was less efficient against *Gasterophilus* spp. larvae than oral ivermectin (*Xiao et al.* 1994, *Monahan et al.* 1996). While abamectin injection had high efficacy against biting lice, *Bovicola bovis,* no effect was seen following moxidectin injection (*Titchener et al.* 1994). The dung from moxidectin treated cattle was also less toxic to various insects than the dung from ivermectin treated cattle (*Strong & Wall* 1994). Therefore, it has been claimed that the anthelmintic and acaricidal properties of moxidectin are generally superior to its insecticidal properties (*Shoop et al.* 1995).

Whether the unsatisfactory efficacy against warbles and throat bots depends solely on the intrinsic lower efficacy of moxidectin against insects, cannot be stated. Moxidectin is also more lipofilic than ivermectin (*Hayes* 1994), and reindeer during the winter are generally on a negative energy balance consuming their fat reserves. Therefore, it seems possible that another reason for the inadequate efficacy might be in the pharmacokinetics of moxidectin in weight-losing reindeer. Pharmacokinetics of moxidectin in reindeer should be examined before conclusions can be drawn. The efficacy of

Table 1. Geometric means and efficacy of endectocide treatment against various parasites in Kaamanen reindeer hinds 1991-92. The number of *Hypoderma tarandi* and *Cephenemyia trompe* counted in live animals.

	Group[a]		
Parasite	Control	Moxidectin	Ivermectin
Hypoderma tarandi	39.3	2.85	0
% reduction	–	92.8	100
Cephenemyia trompe	13.7	4.0	0
% reduction	–	70.8	100
Trichostrongylid FECM[b]	56.3	4.3	2.8
% reduction	–	92.3	95.1

[a] Control, no treatment. Moxidectin 200 μg/kg on December 16. Ivermectin 200 μg/kg on December 16.
[b] Faecal Egg Count Mean = (FEC(Jan) + FEC(Feb) + FEC(Mar) + FEC(Apr) + FEC(May))/5.

Table 2 Weights (kg) of the reindeer hinds and their calves of the control and treatment groups in Kaamanen 1991-92.

	Group[a]		
	Control	Moxidectin	Ivermectin
Weight Day 0[b]	75.4 (1.9); 13[c]	76.9 (2 8), 13[c]	78.1 (2.8), 14
Growth to Day 130	1.8 (1 5); 13	1.0 (0.8); 13	0.8 (1.3); 14
——[d]	0.5 (0.9); 12	1.0 (0.8); 13	1.7 (1.0); 13
Calf birth weight	5.24 (0.21); 10	5.55 (0.25); 12	5.63 (0.29); 11
Calf weight Sep 18[e]	48.9 (3.4); 7	50.2 (2.1); 11	47.6 (1 7); 10
Calf weight Dec 14[f]	42.5 (2.5); 6	46.6 (2.4); 8	45.3 (15); 9

[a] Control, no treatment. Moxidectin 200 μg/kg on December 16. Ivermectin 200 μg/kg on December 16.
[b] Mean (standard error of the mean); number.
[c] The eventually missed two animals excluded
[d] Omitting the two extreme values (see text).
[e] All calves were not found in September due to the herd being spread.
[f] Some calves were slaughtered in November (normal procedure for the herd).

moxidectin in fattening reindeer in early autumn against warbles and throat bots might also be worth evaluating.

Although the mean weight gain of untreated control animals was highest, this may at least partly be caused by parasite biomass. Typically, a third instar warble weighs 1600 mg (*Breyev* 1961) and it is associated with host tissue reaction. *Nordkvist* (1967) estimated that warbles alone could make up to 500 g in one animal. After removal of 2 animals with extreme weight gain or weight loss, there is a weak positive effect of treatment in both weight gain and calf birth weight.

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Sammendrag

Moxidektin som endektosid i rein

I desember 1991 ble 42 reinsdyrsimler fra Kaamanen forsøksflokk delt i tre grupper En gruppe var ubehandlet, mens de to andre gruppene ble behandlet subkutant enten med moxidektin eller ivermektin med dose 200 μg kg^{-1} Effekten av behandlingen ble vurdert etter månedlige fæcesundersøkelser for nematode-egg til mai (1992) og etter telling av hud- og nesebremslarver (*Hypoderma tarandi* og *Cephenemyia trompe*) Moxidektin hadde lavere effekt mot hud- og nesebremslarver (92.8% respektive 70 8%) enn ivermektin (100% mot begge arter) Både moxidektin og ivermektin hadde høg effekt mot eggproduksjon av gastro-intestinale trichostrongylider, hvilket indiserer høg effekt mot både voksne og inhiberte trichostrongylider. Det var ikke signifikante forskjell mellom vektutvikling hos simler eller fødselsvekter hos kalver.

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