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From the Institute of Veterinary Microbiology and Hygiene,
Royal Veterinary and Agricultural University, Copenhagen, Denmark.

BOVINE DICTYOCAULOSIS

PATTERN OF INFECTION AND THE PREVENTION OF PARASITIC BRONCHITIS*

By

Rolf Jess Jørgensen

JØRGENSEN, R. J.: *Bovine dictyocaulosis. Pattern of infection and the prevention of parasitic bronchitis.* Acta vet. scand. 1980, *21*, 658—676. — A combined epidemiology and control investigation was performed with parasite-free calves turned out in May on a permanent pasture naturally contaminated with lungworm larvae the previous year. Before the start the field was divided into two plots. One plot was grazed by 12 calves after the first week of May. The other plot was grazed by 12 calves turned out two weeks later. Both groups as well as the plots grazed by them were subdivided six weeks after turning out. Based on a predicted rise in the pasture larval contamination with infective lungworm larvae, one subgroup of each main group was given a tactical anthelmintic treatment six weeks and again eight weeks after their date of turning out. Patent infections from overwintered larvae were detected in both main groups after four weeks of grazing, but not in all individuals of the late turned-out group. The excreted larvae gave rise to pathogenic pasture larval contaminations on the two initial plots five to six weeks after turning out. In the control groups, early turning-out resulted in approx. 10 times higher larval recoveries in faeces and pasture compared to late turning-out. Seven to eight weeks after turning-out critical, severe parasitic bronchitis had developed in the early turned-out control group. In the late turned-out controls, clinical signs were obvious but not critical. Outbreaks were not observed in any of the experimental subgroups, and no larval excretion was observed among them within four to five weeks following treatments. Similarly, no larvae were recovered from their pastures two weeks after treatment and onwards. A third treatment was given to both experimental groups on the same date (August 21) to suppress gastrointestinal parasitism. However, the level of this infection appeared moderate, probably due to comparatively low precipitation and extensive supplementary feeding given in late summer to compensate for scarcity of grass.

Dictyocaulus viviparus; parasitic bronchitis in calves; epidemiology; tactical treatment; control.

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Epidemiological studies dealing with the course of lungworm infection in calves and the corresponding pasture larval contamination during the grazing season have been carried out in western Scotland (*Duncan et al.* 1979) and in Denmark (*Jørgensen* 1980 a).

In the Danish investigations carried out in 1974 and 1975 the pasture larval contamination was studied in detail. It was observed to reach pathogenic levels five to seven weeks after the initial infection. A similar finding was made in an investigation in 1978 where all calves were given a mild infection (2—3 L_2/kg) when turned out. In that experiment the pasture contamination reached lethal levels within six weeks (*Jørgensen* 1980 b).

In the present experiment two main groups of parasite-free calves were turned out in May 1979 on a pasture contaminated the previous autumn (*Jørgensen* 1980 b). The groups were turned out with an interval of two weeks in order to follow the influence of the date of turning-out on the course of the infection. Based on the experiences mentioned above, a pathogenic pasture larval contamination was predicted to occur five to seven weeks after turning-out, provided infective larvae would overwinter and produce patent infections in the two groups. Furthermore, it was attempted to prevent the development of clinical parasitic bronchitis in both groups by dosing with an anthelmintic six weeks after turning-out and again two weeks later. A third treatment of both experimental groups was planned to suppress gastrointestinal parasitism. The date of this treatment was not decided beforehand, but would depend on the appearance of clinical signs.

MATERIALS AND METHODS

Meteorology

Climatic recordings were obtained from a meteorological station situated 500 m away from the experimental field. Recorded temperature and precipitation are shown in Fig. 1.

Grass availability and supplementary feeding

Grass became scarce in July as a result of the relatively high stocking rate and low rainfall. From this time and onwards all groups received 20 kg of hay per week as a supplementary feeding. In addition, 10 kg of concentrates were given twice a week to each group from mid-August and onwards.

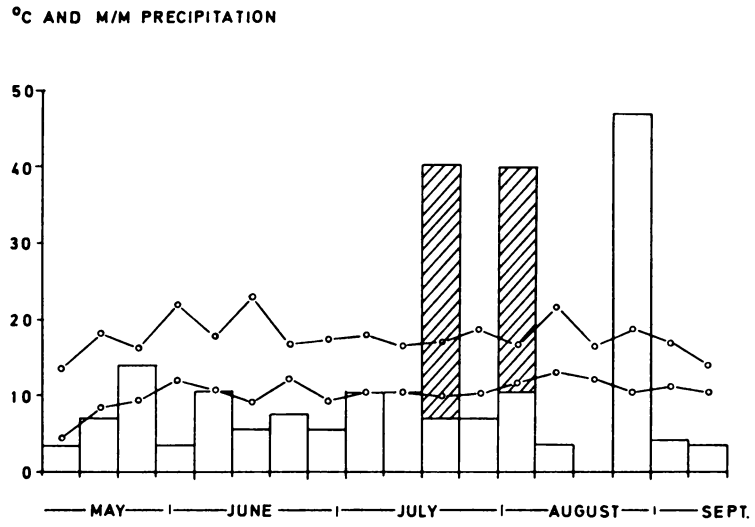


Figure 1. Daily maximum and minimum temperatures, plotted as weekly means. Weekly precipitation shown in histogram. The shaded areas indicate artificial watering of the N-plots.

Site

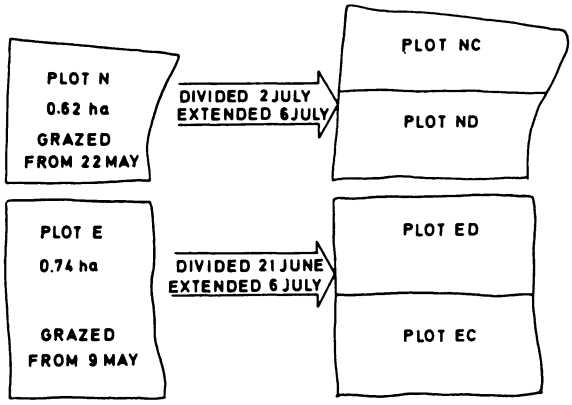
A low-lying, but well drained field surrounded by a deer-proof fence was used. During the previous summer and autumn it had been contaminated by calves with patent verminous bronchitis. The details of this outbreak are published elsewhere (*Jørgensen* 1980 b). Pasture sampling during the period October 1978—May 1979 showed a marked decrease in the contamination with infective Dictyocaulus viviparus larvae from approx. 10,000 to less than 10 per kg of fresh herbage picked around faecal pats during the period October 78—May 79. The field was divided into Plots N and E (Fig. 2).

Animals

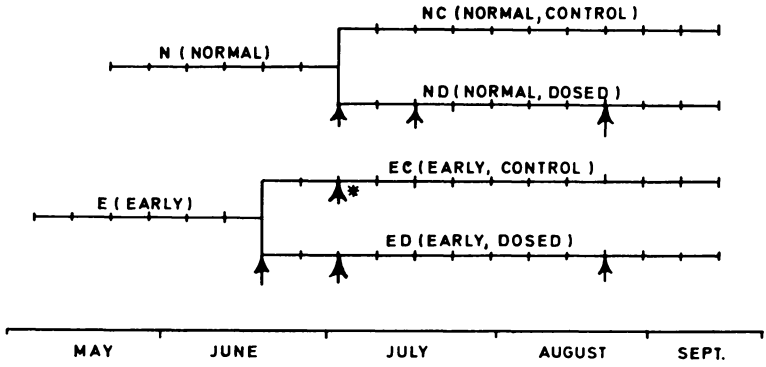
Twenty-eight indoor-reared male Jersey calves with an average bodyweight of 120 kg were used. Four Jersey calves of a similar size were used as tracers.

Design and management

Fourteen calves were turned out on Plot E (Figs. 2 and 3) on May 9. Two of the calves which served as tracers were housed after two weeks of grazing, and after a further two-week period



F i g u r e 2. The experimental field. To the left is shown the initial division into two plots (N and E) each grazed by 12 calves. To the right the divided and extended plots each grazed by subgroups of six calves each.



F i g u r e 3. Experimental design and anthelmintic tactics. Letters indicate groups of calves as well as plots grazed by them. The D-subgroups were treated tactically against verminous bronchitis after their sixth and eighth week on pasture. A third treatment was given to both D-subgroups simultaneously (August 21) to suppress gastrointestinal parasitism. All treatments were carried out with fenbendazole susp. 10 % (Panacur® Hoechst) at a dose of 7.5 mg/kg bodyweight.
↑ * therapeutic treatment given to Group EC after eight weeks on pasture. It was not part of the tactic, but was given to avoid cases of death due to severe verminous bronchitis.

their lungs were examined post mortem for the presence of lungworms.

The remaining 14 calves were turned out on May 22 on Plot N. Two of these calves also served as tracers for the first two-week period grazed by this group.

After six weeks on pasture, i.e. June 19 and July 3, respectively, Group E and Group N and the plots grazed by them were subdivided. Tactically dosed subgroups (Group ED and Group ND) and control groups (Group EC and Group NC) each consisting of six calves were treated as shown in Fig. 3 and grazed separately after their sixth week on pasture until September 11. An extension of approx. 40 % in area was added to each of the four fields on July 6. A hay crop had been taken from this part of the field two weeks previously.

Methods

The pastures as well as the animals were sampled at weekly intervals. Sampling and laboratory methods were carried out as in previous experiments (*Jørgensen* 1980 a). The influence of laboratory variation on the results was reduced by dividing each faecal sample as well as each pasture sample sediment before separate laboratory processing of the split samples. Post-mortem gastrointestinal worm counts were carried out on aliquots of contents and digests obtained by standard techniques (*Anon.* 1971), cleared by sieving through a 36 µm aperture test sieve and stained and decolourized according to Jørgensen (*Jørgensen* 1975). Adults and immatures were collected from lungs by a modification of the perfusion technique (*Inderbitzin* 1976). With the author's modification tap water is pumped into arteria pulmonalis, after vena pulmonalis has been tied off. Due to the increased pressure the respiratory membranes burst and the worms are flushed out of the trachea.

RESULTS

Tracer calves

At post-mortem examination of the tracer calves, 28 and 10 lungworms were found in the pair which grazed during the period May 9—22, and 29 and 0 lungworms were found in the pair grazing from May 22 to June 5. The size distribution of these worms is shown in Fig. 9 together with worms recovered from the E-groups.

Clinical observations

E g r o u p s. Some coughing was heard occasionally among calves of Group E after six weeks. After the seventh week, i.e. one week after the calves were split into Subgroups ED and EC, mild but typical symptoms of verminous bronchitis had developed in Group EC whereas Group ED appeared symptomless. Two days later (June 28) obvious clinical signs had developed in Group EC. The calves of this group were seen standing most of the day, and grazing was interrupted frequently by coughing. In contrast, Group ED either grazed or was observed to lie down and ruminate. On July 3, i.e. after eight weeks on pasture, the condition of Group EC had developed to a critical stage, and it was decided to treat it on that date in order to prevent cases of death. As a result of this treatment, the difference in clinical condition during the rest of the summer was per se limited to slightly more coughing among calves of Group EC. Respiratory rates of the four groups are summarized in Fig. 4. The difference between

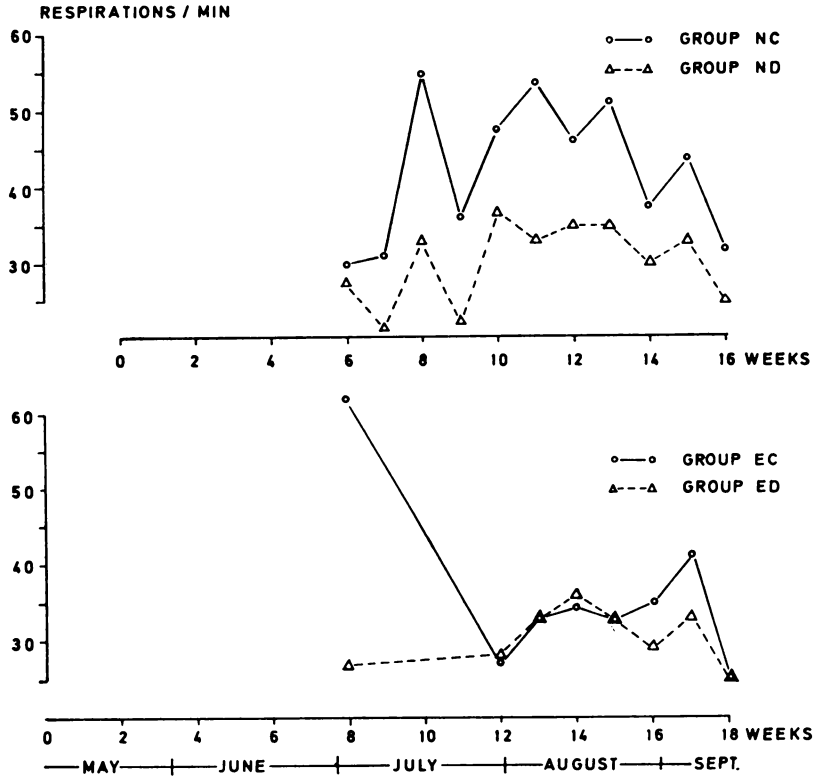


Figure 4. Respiratory rates of Groups NC, ND, EC and ED.

the E-groups after eight weeks on pasture resulted from the first tactical treatment of Group ED two weeks previously. The difference disappeared when Group EC received its therapeutical treatment. A minor difference was recorded later, in early September.

N groups. The first signs of verminous bronchitis were observed in the control group after seven weeks. One week later the symptoms were obvious, and coughing and elevated respiration was noted during the rest of the summer (Fig. 4). The infection never reached a critical stage during the period of observation. On September 11, several calves had developed semi-fluid faeces indicating a pathogenic level of ostertagiasis. Two weeks after the experiment was terminated, one of the calves was euthanized. It had shown an aggravation of its respiratory signs despite anthelmintic treatments. Post-mortem examination revealed pronounced lung emphysema together with peribronchial eosinophilic and plasma cell infiltrations. In contrast, Group ND, the experimental group, remained in good condition and showed no signs of verminous bronchitis during the experiment, with the exception of a few coughs during the eighth and ninth weeks.

Larvae in faeces and pasture

The mean number of D. viviparus larvae found in the faeces of the four groups is presented in Fig. 5 and the individual faecal larval counts are shown in Tables 1 and 2. In the N-group as well as in the E-group the first larvae were detected after week 4. The larval excretion after weeks 4, 5 and 6 was approx. 10 times higher in the E-group than in the N-group, indicating a higher uptake of overwintered larvae. No larvae were detected for several weeks following anthelmintic treatment. However, reshedding of larvae occurred four to five weeks after treatment.

In contrast to the E-group, larvae were not detected in all calves of the N-group initially (Table 1). In the latter group the initial larval excretion was extremely low. No larvae were detected in calf No. 76 during the first seven weeks and in calves 72 and 73 during the first eight weeks on pasture. Table 1 also shows that the untreated Group NC remained patent for the rest of the summer.

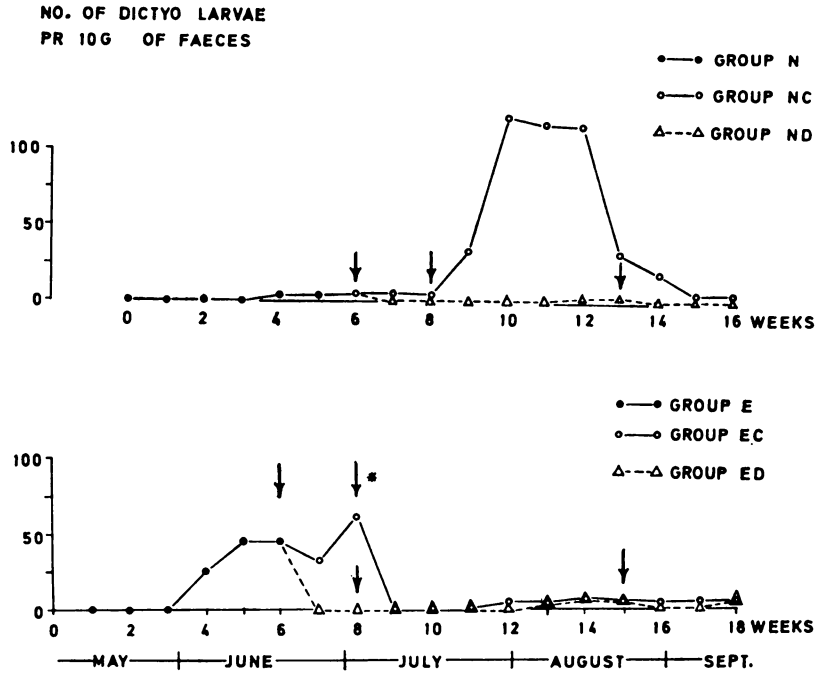


Figure 5. Mean faecal larval counts of the experimental groups. Arrows indicate tactical treatments of the respective D-groups. The arrow marked with * indicates therapeutic treatment of Group EC.

The pasture contamination with infective D. viviparus larvae is shown for the various plots in Figs. 6 and 7. The last overwintered larvae were found on May 15. The new generation appeared after five weeks of grazing although a few larvae were recovered near faecal pats on the E-plot already after four weeks of grazing. On both fields the contamination increased during the fifth and sixth weeks. The horizontal distribution of larvae appeared to be similar, but the level was approx. 10 times higher on the E-field than on the N-field. This was similar to the differences in faecal larval counts during the period of weeks 4, 5 and 6. The samples taken from fields grazed by dosed calves became negative after the sixth (Plot ND) and the ninth weeks (Plot ED) and remained so for the rest of the experiment. The larval excretion of Group NC resulted in a significant but poorly distributed pasture contamination. On Plot EC a few larvae were recovered again in late summer around faecal pats.

Table 1. Individual faecal larval counts (larvae per 10 g) of the calves of the N-groups. Double Baermannization (2×10 g) was performed on each sample.

		Dates: May		June				July					August				September	
		22	29	6	12	19	26	4	10	17	24	31	7	15	21	28	4	11
Group	Calf No.	Weeks grazed: 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
						0		3							2			
ND	41	0	0	0	0	2	0	7	0	0	0	0	0	0	0	0	0	0
							13	15						4	6			
	42	0	0	0	0	0	23	26	0	0	0	0	0	0	13	0	0	0
						0		1										
	43	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
						0	25	5						1	0			
	44	0	0	0	0	9	0	6	0	0	0	0	0	2	1	0	0	0
							0								7			
	45	0	0	0	0	0	1	0	0	0	0	0	0	0	9	0	0	0
						0	1	7										
	46	0	0	0	0	1	4	11	0	0	0	0	0	0	0	0	0	0
							6	8	24	10	50	228	145	104	42	45	10	17
NC	71	0	0	0	0	0	9	9	27	17	74	187	225	102	28	75	2	15
											15	27	1	9	0	2		1
	72	0	0	0	0	0	0	0	0	0	11	33	7	3	3	4	0	0
											25	138	354	529	100	42	1	2
	73	0	0	0	0	0	0	0	0	0	20	122	337	610	215	72	0	0
							1	2	0		19	34	33				1	2
	74	0	0	0	0	0	2	4	1	0	9	32	61	0	0	0	0	0
							1	2	1		1	3	1					
	75	0	0	0	0	0	1	8	1	0	3	2	3	0	0	0	0	0
										10	75	401	125	30	3	3	4	2
	76	0	0	0	0	0	0	0	0	17	127	262	118	19	11	8	0	2

Table 2. Individual faecal larval counts (larvae per 10 g) of the calves of the E-groups. Double Baermannization (2×10 g) was performed on most samples.

		Dates: May				June				July					August				September	
		9	15	22	29	6	12	19	26	4	10	17	24	31	7	15	21	28	4	11
Group	Calf No.	Weeks grazed: 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
						0		26	0	0	0		0	0		0	0	0	0	0
ED	51	0	0	0	0	0	41	39	0	0	0	n.d.	0	0	n.d.	0	0	0	0	0
						36	9	76	0	0	0	0		0	0	0	0	0	0	0
	52	0	0	0	0	47	72	60	0	0	0	0	0	0	0	0	0	0	0	0
						20	8	21	0	0	0	0		0	0	1	2	0	0	0
	53	0	0	0	0	15	2	10	0	0	0	0	0	0	0	3	0	0	0	1
						74	90	265	0	0	0	0	0	0	0	0	0	0	0	0
	54	0	0	0	0	46	192	213	0	0	0	0	0	0	0	0	0	0	0	0
						9	23	30	0	0	0	0		0	0	1	3	0	0	0
	55	0	0	0	0	11	100	32	0	0	0	0	0	0	0	1	0	0	0	0
						2	10	26	0	0	0			0	0	18	7	0	0	0
	56	0	0	0	0	1	10	46	0	0	0	n.d.	0	0	1	12	9	0	0	0
						62	57	0	4	12		0		0	0	2	0	0	0	0
EC	31	0	0	0	0	57	82	18	5	13	n.d.	0	0	0	0	1	0	1	0	0
							16	79		281	0	0		0	6	11	4	1	0	0
	32	0	0	0	0	3	66	48	n.d.	252	0	0	0	1	7	16	4	1	0	2
						8	34	76	18	46	0	0		0	1	15	11	4	13	1
	33	0	0	0	0	8	52	11	27	65	0	0	0	0	2	20	4	7	4	0
						5	44	22	16	5	0	0	0	0			0	0	0	0
	34	0	0	0	0	14	69	12	21	3	0	0	0	0	0	0	0	0	0	0
						4	3	6	1	29	0	0		0	0	0	0	0	0	0
	35	0	0	0	0	18	30	2	2	29	0	0	0	0	0	0	0	2	0	0
						63	2	22	0	1	0	0		0	0		0	0	0	0
	36	0	0	0	0	73	8	37	0	4	0	0	0	0	0	0	0	0	0	0

n.d. = not done.

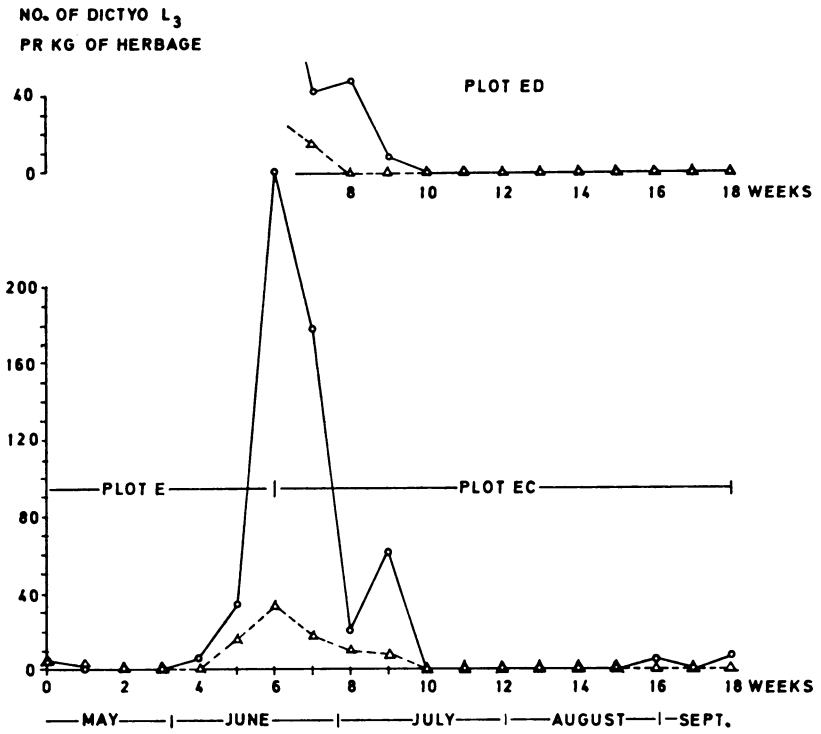


Figure 6. Pasture contamination of the E-plots with infective D. viviparus larvae. ○: Samples picked 5 cm away from faecal pats. △: Samples picked at least 100 cm from faecal pats.

Weight gains

As a result of the outbreak of verminous bronchitis in Group EC these calves lost an average of 8 kg during weeks 7 and 8, compared to an average gain of 7 kg in Group ED during the same period. At the end of the experiment the difference was reduced to 5 kg, probably due to the early therapeutic treatment, to the supplementary feeding and to the absence of pathogenic levels of trichostrongyle larvae in the pastures grazed by the two groups.

In the N-groups where clinical signs of verminous bronchitis were obvious after eight weeks, Group NC gained 3 kg only during the remaining eight weeks of the experiment despite supplementary feeding during that period. Patent verminous bronchitis and pathogenic levels of gastrointestinal parasitism are both likely to be responsible for this low weight gain. By way of comparison Group ND gained 31 kg during the last eight weeks.

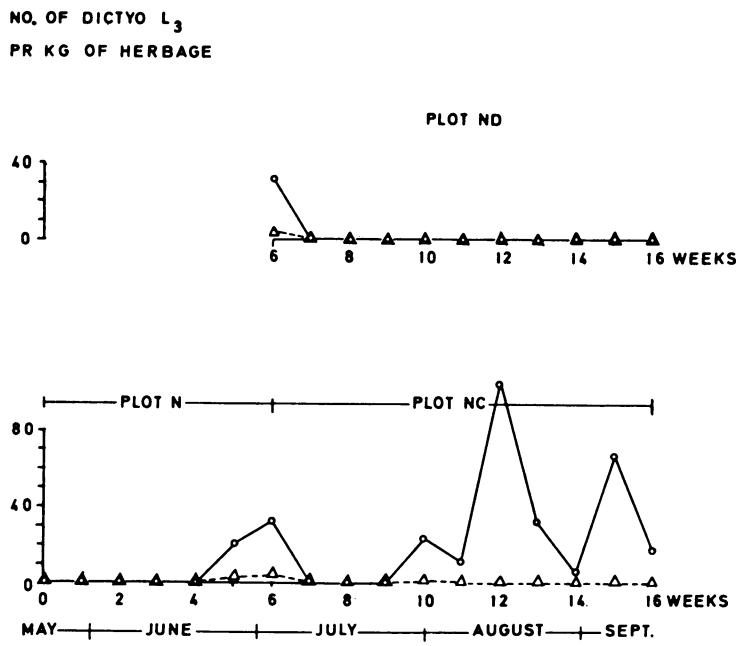


Figure 7. Pasture contamination of the N-plots with infective D. viviparus larvae. ○: Samples picked 5 cm away from faecal pats. △: Samples picked at least 100 cm from faecal pats.

Gastrointestinal parasitism and herbage contamination with L_3 of trichostrongyles

Due to the low rainfall, the pasture contamination with L_3 of trichostrongyles did not reach significant levels on the E-plots. On the N-plots moderate levels were encountered as shown in Fig. 8, due to artificial watering of these plots on two occasions. The figure shows peaks in late summer on Plot NC close to faecal pats after periods of high precipitation. The anthelmintic strategy applied in Group ND apparently suppressed the contamination in late August and in September in that the peaks seen in the pasture close to faeces were greatly suppressed or absent.

The mean faecal egg counts of the E-groups remained low. In Group EC it rose to a level of 100 eggs per g (EPG), compared to 250 of Group ED after week 18. In the late turned-out groups the egg counts rose to more than 600 EPG (week 16) in the control group, whereas it remained lower than 100 per g in Group ND during the whole experiment.

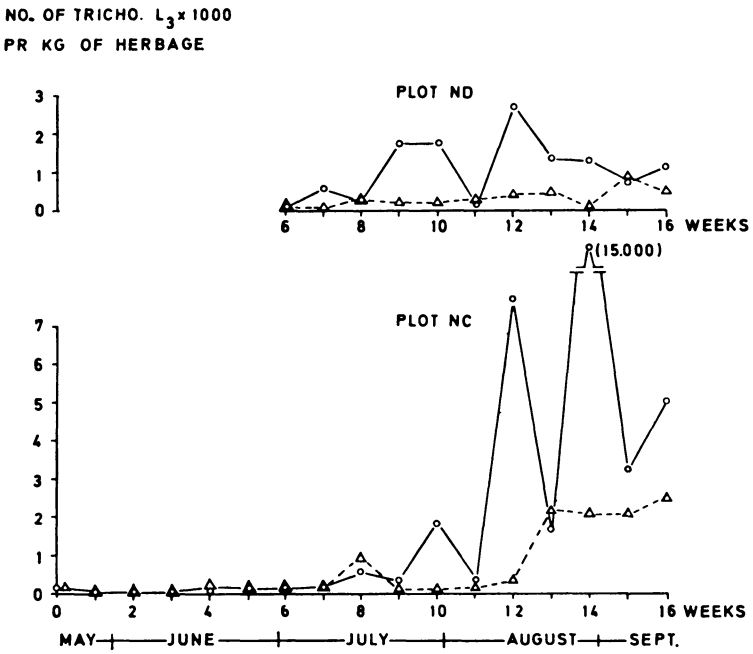


Figure 8. Pasture contamination with trichostrongyle L_3 of the N-plots. The calves on Plot ND received anthelmintic after the sixth, the eighth and the 13th week. ○: Samples picked 5 cm away from faecal pats. △: Samples picked at least 100 cm away from faecal pats.

Post-mortem worm counts

Post-mortem worm counts were carried out on the E-groups. The results are shown in Table 3. The differences between the groups may be the result of the anthelmintic strategy directly on an existing worm burden as well as indirectly through its effect on the pasture larval contamination. The size distribution of recovered lungworms is compared with worms recovered

Table 3. Abomasal and lung worm counts of the E-groups determined on Steptember 19, i.e. four weeks after Group ED received its last treatment.

	Abomasum (digests + lumen)		
Group	immatures mean ± s	adults mean ± s	Lungs mean (range)
ED	8,000 ± 3,500	7,200 ± 5,200	1 (0—3)
EC	56,100 ± 30,000	27,700 ± 12,000	12 (2—34)

from the four tracers in Fig. 9. It shows that most worms recovered from the continuously grazing calves were only half the size of those recovered from the tracers.

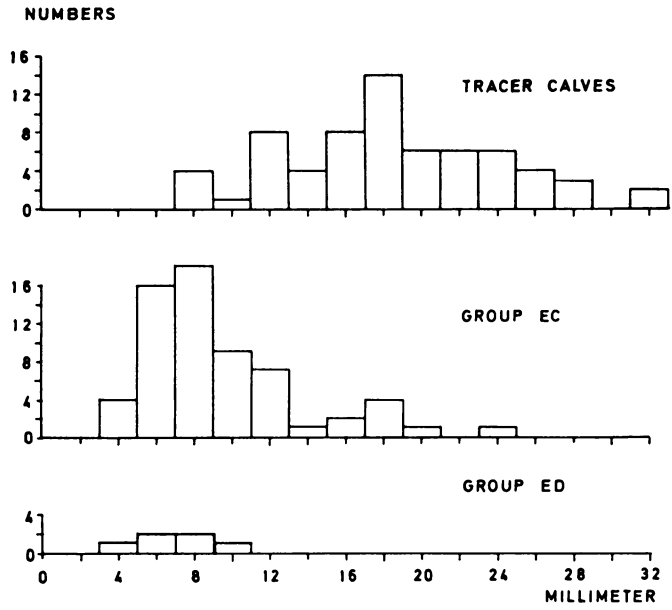


Figure 9. Size distribution of lungworms recovered from the E-groups as well as from four tracer calves.

DISCUSSION

The initial lungworm infection in the present experiment obviously originated from the uptake of overwintered larvae. In the calves turned out after the first week of May patent infections were detected in the faeces of all the continuously grazing calves four weeks later as well as in the lungs of the two tracers which grazed the first two weeks. The calves turned out after the third week of May showed an extremely low initial larval excretion. Apparently the infectivity of the overwintered pasture contamination had fallen to a level where it produced detectable patent infections in some, but not in all of the continuously grazing calves. Similarly, no worms were found in one of the two tracers which were turned out on the same date. These observations show that the extent to which the overwintered pasture larval contamination was perpetuated to the grazing stock was determined by the time of turning-out. They also indicate that

the number of calves may play a role for the perpetuation of the infection if the overwintered pasture contamination is disappearing at the time the new stock is turned out. An initial situation similar to the one in the NC-group was observed in 1974 (*Jørgensen* 1980a).

The low level of or in some individuals the absence of larval excretion in the continuously grazing calves prior to the development of verminous bronchitis and the low worm burden of the tracer calves support the view that the observed clinical disease resulted from recent uptake of contaminated herbage rather than from the uptake of overwintered larvae. Similar observations supported by post-mortem findings were made in an experiment carried out in 1978 (*Jørgensen* 1980 b). The predicted rise in the pasture contamination during weeks 5 and 6 approx. two weeks prior to the development of obvious clinical signs and the direct relationship between the magnitude of the pasture infections and the severity of clinical symptoms evidently point in the same direction.

The pathogenic pasture contaminations on Plots E and N were similar in their horizontal distribution and corresponded well in magnitude to the faecal larval excretion from which they originated. This indicates equally favourable conditions for L_3 development and translation in early June as well as in mid-June.

The further course of the infection in the NC-group and -plot was similar to that experienced in a study carried out in 1975 (*Jørgensen* 1980 a) in that it was characterized by a poor horizontal distribution of larvae in the pasture during a relatively long period of patency. As in the 1975-experiment, the poor distribution may be explained by insufficient moisture. The moisture conditions in the N-plots, aided by artificial watering, were on the other hand sufficient to allow the build-up of a significant pasture contamination with L_3 of trichostrongyles although it was largely concentrated around the faecal pats.

The size distribution of the lungworms recovered from the tracers shows worm growth similar to that seen in susceptible calves killed during the third or fourth week following experimental primary infection. The finding that most of the worms from the continuously grazing calves were only 5 to 10 mm in size, is interesting. They are distinctly larger than the arrested larvae found by *Pfeiffer* (1971, 1976), by *Supperer & Pfeiffer*

(1971) and by *Inderbitzin* (1976) since they all report on immatures with a length of less than 5 mm. Perhaps they are similar to the "stunted" worms found by *Gupta & Gibbs* (1975) in bovines with a similar history, although no measurements were given by these authors. The timing of the first two tactical treatments in the experiment was based on the prediction from previous experiences (*Jørgensen* 1980 a, b) of the pathogenic pasture larval contamination, and the successful prevention of clinical disease is explained by the effect of the treatments on the previously mentioned recently acquired superinfections rather than on the light patent primary infections originating from overwintered larvae. However, the treatments also eliminated the excretion of larvae for a least a month, judged by the results of the faecal examinations. Due to the rapid disappearence rate of D. viviparus pasture larvae during the summer conditions and the lack of larval output following treatments, no larvae were demonstrated in the herbage samples picked during the rest of the summer. Consequently the calves were not re-exposed to infective larvae in significant numbers. The extremely low levelled reshedding of larvae seen later in some of the calves of the D-groups may have two origins, either from larvae picked up after the eighth week or from developing stages which survived the anthelmintic dosings. A third possibility is that it resulted from both sources.

The timing of the third treatment was decided during the experiment, after the first relatively high pasture counts of L_3 of trichostrongyles were seen together with loose faeces in some of the calves in Group NC. The treatment was given to both experimental groups on the same date since the rise in the pasture contamination with L_3 of trichostrongyles in Denmark and elsewhere in northern Europe is seasonal and takes place from mid-July and onwards (*Rose* 1962, *Anderson et al.* 1965, *Michel* 1967, *Henriksen et al.* 1976, and others) and is governed by climatic conditions rather than the time of turning-out.

A full appraisal of the third treatment as a supplement to the ones given after weeks 6 and 8 would require subdivision of the treatment groups. However, the grazing period was shortened due to scarcity of grass. This as well as the supplementary feeding may explain the comparatively low level of gastrointestinal parasitism.

The differences in weight gain figures between the treatment

groups and their control groups are probably of limited value in the evaluation of the treatments or in drawing conclusions on the pathogenicity of the lungworm infections towards weight gains. This is partly because Group EC was treated at an early stage due to close supervision and because the calves in Group NC were observed to consume considerably more hay than Group ND. Obviously they preferred the hay rather than grazing due to their respiratory discomfort.

The results of the present experiment raise an important question, namely the extent to which the preventive effect of the anthelmintic tactic is applicable to the condition under which outbreaks of verminous bronchitis occur on farms. Although investigations on farm outbreaks have been carried out in the past (*Taylor* 1951, *Jarrett et al.* 1954, *Michel & Shand* 1955, *Larsen* 1960, *Pfeiffer* 1971, *Winters & Worley* 1975) information on the epidemiological circumstances prior to outbreaks including information on when and from where the pathogenic infections are acquired, is limited. Possible sources of the initial infection were discussed by *Duncan et al.* (1979) in connection with recent studies carried out in west Scotland. In Denmark *Henriksen & Andersen* (1979) found that the percentage of positive faecal samples submitted by Danish practitioners over a 15-year period culminated in July-August which may be taken as an indication that pathogenic infections are picked up early in the season as in the present study.

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SAMMENDRAG

Bovin dictyocaulose. Infektionsmønster samt forebyggelse af verminøs bronkitis blandt kalve.

Et kombineret epidemiologi- og kontrolforsøg blev udført med parasitfri kalve, der blev bundet ud i maj måned på vedvarende græsareal, der var kontamineret med lungeormlarver fra forrige græsningssæson. Ved forsøgets start blev arealet opdelt i to fenner. På den ene blev udbundet 12 kalve første uge i maj. De resterende kalve blev udbundet på den anden fenne to uger senere. Begge grupper samt deres respektive fenner blev underopdelt seks uger efter udbinding. En stigning i markernes kontamination med infektive lungeormlarver var forudset. Baseret herpå modtog den ene undergruppe af hver af hovedgrupperne en taktisk anthelmintisk behandling seks uger samt igen otte uger efter de var blevet bundet ud. Fire uger efter udbindingen påvistes patent lungeorminfektion i begge hovedgrupper men ikke blandt alle kalvene i den senest udbundne hovedgruppe. De udskilte larver gav anledning til en patogen græsmarkssmitte med infektive lungeormlarver i begge hovedfennerne efter fem-seks ugers afgræsning. Blandt kontrolgrupperne medførte tidlig udbinding ca. 10 gange så højt smitteniveau, både i fæces- og i græsprøverne, sammenlignet med udbinding to uger senere. Syv-otte uger efter udbindingen konstateredes svær verminøs bronkitis blandt den tidligt udbundne kontrolgruppe. I den sene kontrolgruppe var de kliniske symptomer markante, men kalvenes tilstand var ikke kritisk. Udbrud og symptomer udeblev blandt begge forsøgsgrupperne, og der kunne ikke påvises larveudskillelse fire-fem uger efter behandlingerne, ligesom der ikke påvistes larver i græsprøverne to uger efter behandlingerne eller senere. En tredie behandling blev givet til begge de eksperimentelle undergrupper på samme dato (21. august) for at nedbringe smitteniveauet med løbe-tarmorm. Dette smitteniveau viste sig imidlertid at være lavt, formentlig p. g. a. ringe nedbør, og fordi kalvene modtog betydelige mængder tilskudsfoder sidst i græsningssæsonen grundet græsmangel.

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Reprints may be requested from: Rolf Jess Jørgensen, the Institute of Veterinary Microbiology and Hygiene, Royal Veterinary and Agricultural University, Bülowsvej 13, DK-1870 Copenhagen V, Denmark.