Parasites in Sheep in the Faroe Islands

Síkar á seyði í Føroyum

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Úrtak

Á heysti 1998 vórðu sýnir tikin av 15 lombum við tí endamáli at staðfesta møguliga sníkufongd. Veturin, várið og heystið 1999 vóru tøðvertir tiknir frá tilsamans 226 lombum og óm. Hesir vórðu kannaðir fyri ormaegg, lungaormalarvur, coccidiuegg og iglaegg. Útvortissníkar, funnir í hesum sambandi, vórðu eisini skrásettir. Kanningarnar staðfesta, at seyður í Føroyum er fongdur við niðanfyri nevndu sníkum. Rundormar í vinstur: *Teladorsagia circumcincta, T. trifurcata, T. davtiani* og *Trichostrongylus axei.* Rundormar í vilum: *Trichostrongylus vitrinus, Nematodirus battus* og *N. filicollis.* Rundormar í skarngørnum: *Chabertia ovina, Oesophagostomum venulosum* og *Trichuris ovis.* Rundormar í lungum: *Dictyocaulus filaria* og *Muellerius capillaris.* Bendilormur í vilum: *Moniezia expansa.* Bendilormur í búkrúmi: *Cysticercus tenuicollis* (*Taenia hydatigena*). Coccidiur í vilum: *Eimeria* spp. Iglar í livur: *Fasciola hepatica.* Útvortissníkar: *Bovicola ovis* (ullalús) og *Melophagus ovinus* (førilús). Nógv er, sum bendir á, at skrubbmottan, *Psoroptes ovis,* er á seyði í Føroyum, hóast hon ikki er funnin í hesari kanningini. Úrslitið av hesi verkætlan gevur okkum eina hilling á, hvussu støðan er við sníkum á seyði í Føroyum, men djúptøknari og nágreiniligari kanningar eru neyðugar, skulu vit fáa eina hollari fatan av samanspælinum millum sníkar og seyð og av sníkutrupulleikanum sum heild.

Abstract

In the autumn of 1998, samples from 15 lambs were studied post mortem for the presence of endoparasites. In the winter, spring, and autumn of 1999, faecal samples were collected from 226 lambs and ewes and were searched for the presence of nematode eggs, *Eimeria* oocysts, lungworm larvae, and *Fasciola* eggs. Ectoparasites found in connection with these examinations were also noted. The studies confirm that the following parasites are present in and on sheep in the Faroe Islands. Nematodes in the abomasum: *Teladorsagia circumcincta, T. trifurcata, T. davtiani* and *Trichostrongylus axei.* Nematodes in the small intestine: *Trichostrongylus vitrinus, Nematodirus battus*, and *N. filicollis.* Nematodes in the large intestine: *Chabertia ovina, Oesophagostomum venulosum*, and *Trichuris ovis.* Nematodes in the lungs: *Dictyocaulus filaria* and *Muellerius capillaris.* Cestodes in the small intestine: *Moniezia expansa.* Cestodes in the abdominal cavity: *Cysticercus tenuicollis* (*Taenia hydatigena*). Coccidia in the small intestine: *Eimeria* spp. Flukes in the liver: *Fasciola hepatica.* Ectoparasites: *Bovicola ovis* and *Melophagus ovinus.* There are significant reasons to believe that *Psoroptes ovis* is also present, although it was not found in this study. It is anticipated that these parasites would have a great impact on the health of the sheep in the Faroe Islands, if proper management and medication were not performed. The results of this project contribute to an overall understanding of the parasite population in and on sheep in the Faroe Islands, although extensive study is needed in the future to get a more detailed understanding of the parasite complex and of the epidemiology of the same parasites.

Introduction

The main purpose of this project was to determine which parasites are present in the sheep in the Faroe Islands. Furthermore, an attempt was made to estimate the prevalence of these parasites, and to estimate the possible influence on the health of the sheep. There is very little work done on this topic. In 1919, the official veterinarian in the Faroe Islands was supposed to study the nature of the liver fluke and other parasitic diseases, especially scabies, and abomasal and lung strongylosis in sheep. However, it has not been possible to find anything in writing demonstrating the results of this investigation. In 1927-1928, a project was set up to estimate the prevalence of *Fasciola hepatica*, and in 1929 research was conducted on *Lymnea truncatula*, the intermediate host of *Fasciola hepatica* (Lützen and Bovien, 1934). *Melophagus ovinus* and *Trichodectes sphaerocephalus* are mentioned as being well known parasites of sheep in the Faroe Islands (Jensen *et al.*, 1928-1971).

Sheep (*Ovis aries*) are present on all the islands of the Faroe Islands. Other domestic mammals include cattle (*Bos taurus*), horses (*Equus caballus*), dogs (*Canis familiaris*), and cats (*Felis domesticus*). The blue hare (*Lepus timidus*), the western house mouse (*Mus domesticus*), and the brown rat (*Rattus norvegicus*) are the only wild, land mammals in the islands. (Bloch, 1999)

History

The Faroe Islands consist of 18 islands separated by narrow straits, and are situated at 62°N, 7°W in the North Atlantic. The total area is 1.399 km^2, and the highest peaks of the islands reach from 370 m to nearly 890 m.

It seems that the Faroese sheep are of mixed origin. In *Liber de Mensura Orbis Terrae* (Dicuil, 825) the author describes a set of small islands north of Britain, filled with countless sheep. It is believed that these islands are the Faroe Islands, and that Irish monks brought these sheep from Ireland to the Faroe Islands. The Norse Vikings settled in the Faroe Islands in the beginning of the 9th century and brought with them sheep from Norway.

Svabo (1781-1782) mentions that some time prior to 1615, due to a very harsh winter, there was a great loss of sheep (*Svarta felli*), that nearly eradicated the animals in the Faroe Islands. To compensate for this great loss, sheep were imported from Iceland to the northern islands, and from Shetland and Orkney Islands to the southern islands.

Effersøe (1886) reports that over a period of forty years, from 1846 to 1886, sheep were imported numerous times to the Faroes. The origin of the imported sheep is not stated. In the 1950s, it is reported (Bjørk, 1984) that fishermen illegally imported sheep from Iceland to the Faroe Islands. In 1961, Scottish Blackface sheep were imported from Scotland. It is believed that the chronic progressive degenerative central nervous system disease, scrapie, which is now endemic, was brought to the Faroe Islands with these sheep.

Bearing in mind the mixed origin of

Faroese sheep, it is obvious that a great variety of parasites have had the opportunity to become established in the Islands, the only restricting factor possibly being the Faroese climate.

Materials and methods

Post mortem examinations

During 8-24 October 1998, samples were taken from 15 lambs. The animals came from four different locations, and were from the mixed, native Faroese breed of sheep.

Four lambs were from the village of Saksun, four lambs from Streymnes, and three lambs from Kollafjørður. These were all sheep that had been grazing freely in the open fields in the mountains. Samples were also taken from four lambs grazing solely on limited, fenced pastures (14 lambs and ewes on 1 ha.) in Havnardalur near Tórshavn. Fig. 1.

In connection with the autumn slaughter, samples were taken from the abomasum, ileum, jejunum, colon, coecum and rectum; all samples included content. The sections of the alimentary tract were ligated at both ends to prevent loss of contents or transfer between sections during processing. Moreover, lungs and liver were taken.

Faecal examinations

Faecal samples were collected from the post mortem material. Samples were also collected in the winter (January and February), in the spring (April), and in the autumn (September and October) in 1999. The lambs were about five months old in autumn, eight months old in winter, and 10

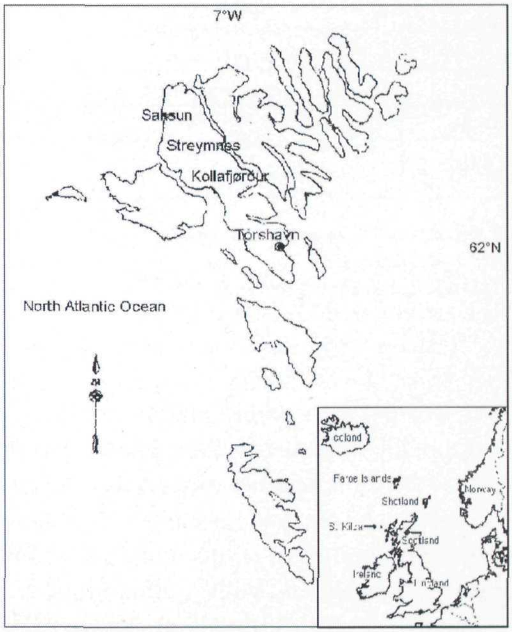

Fig. 1. *Map of the Faroe Islands.*
Mynd 1. Føroyakort.

months old in the spring. Ewes were older than one year. The faecal samples were taken in eight different locations in the autumn, in five different locations in winter, and in six different locations in the spring. The locations were randomly chosen. Samples were obtained directly from the rectum. The total number of sheep examined was 226 lambs and ewes. The distribution of faecal samples collected was as listed in Table 1.

In the spring of 1999, faecal samples were collected from sheep from six different locations. All sheep from three of these locations were last treated with anthelmintics and flukicides in January 1999, and all sheep from the other locations were

	Strongyles, Nematodirus Trichuris and *Eimeria*			*Dictyocaulus* and *Muellerius*			*Fasciola hepatica*		
	Winter	Spring	Autumn	Winter	Spring	Autumn	Winter	Spring	Autumn
Lamb	24	35	79	24	34	64	24	31	0
Ewe	35	28	25	31	28	15	34	27	0

Table 1. *Number of faecal samples collected in 1999. The table groups the samples in season, parasites searched for, and samples from lambs and ewes.*
Talva 1. Tal av tøðvertum tiknir í 1999. Talvan býtir vertirnar sundur í árstíð, hvørjir sníkar leitað hevur verið eftir, og um vertirnir eru av lombum ella óm.

last treated with anthelmintics and flukicides in the autumn of 1998. The treatment was levamisole against nematodes and triclabendazole against *Fasciola hepatica*. The sheep examined in the autumn of 1999, were last treated with anthelmintics - febantel - in the summer of 1999. The sheep examined in the winter of 1999, were last treated with anthelmintics and flukicides - levamisole and triclabendazole - in the autumn of 1998.

Procedures

Abomasum, content

The abomasum was placed in a tray, and split open along the curvatura major. It was emptied, and the mucous membrane was thoroughly washed. The mucous membrane was rubbed gently, to be sure to collect as many as possible of the adult nematodes. Ten percent of the total abomasal content was then poured through a sieve (mesh size of 106 μm). The material was diluted to a known volume of water and coloured and fixed with iodine solution. An aliquot of 1 to 10% – percentage depending on concentration of nematodes – of the retained material was examined under a stereomicroscope and any nematode present was collected and grouped according to gross anatomy. The total number of nematodes in the abomasum was calculated from total sample and aliquots obtained.

Abomasum, mucosal membrane

The mucosal membrane of the abomasum was scraped off and weighed. It was mixed with a digestion solution composed of 1 litre of water, 8 grams of pepsin, and 150 ml of hydrochloric acid 1N, and left to incubate in 40°C for 6-8 hours. The solution was repeatedly stirred during the digestion period. The digested material was then poured through a sieve (mesh size of 38 μm), which retained any larvae present. The number of larvae was determined.

Ileum and jejunum

The small intestine was split in its total length, and the content was emptied into a tray. The mucous membrane was washed in the same way as for the abomasum to recover all nematodes present. An aliquot of 10% was poured through a sieve (mesh size of 106 μm). As for the content of the abomasum, an aliquot of 1 to 10% of the retained material was examined under a stereomicroscope and any nematodes present were collected and grouped, and their total number calculated.

Colon, coecum and rectum
The large intestine was opened and the content washed out and poured through a sieve (mesh size of 212 μm). An aliquot of 50% of the content was searched for nematodes, and their total number calculated.

Lungs
The lungs were examined macroscopically to confirm the possible presence of lungworms and nodular lesions associated with nematode infection. Samples from the nodules were examined microscopically, and the nematode larvae present were identified.

Liver
The liver was cut into two-cm slices, and soaked in lukewarm physiological saline solution for 12 hours. Then the water was poured through a sieve (mesh diameter of 106 μm), to collect any flukes present. Different mesh sizes were used as described above to be sure to retain all possible parasites in the respective organ, but which allowed other material to pass through the sieve.

Abdominal cavity
The abdominal cavity was searched for *Cysticercus tenuicollis* (*Taenia hydatigena*).

Faeces. The faecal samples were examined by the McMaster flotation method (Hansen and Perry, 1994) to determine the number of nematode eggs per gram of faeces (epg) or protozoal oocysts per gram of faeces (opg). Two grams of faeces were collected from the rectum. Twenty-eight ml of flotation fluid (saturated water/NaCl with glucose 50 g per 100 ml) were added to make approximately 30 ml in total. It was mixed thoroughly. The McMaster counting chamber was filled with the mixed sample (0.15 ml). After five minutes, the sample was examined under a microscope at 100 times magnification, and nematode eggs and *Eimeria* oocysts were counted. By multiplication of the number of eggs or oocysts counted in both counting chambers by 50, the estimated total number in 1 g of faeces was found.

A modified Baerman analysis (Hansen and Perry, 1994) was used to isolate larvae from the faeces. Ten grams of faeces were placed on two layers of gauze. The faeces, packed in the gauze, were then dipped into a conical beaker filled with lukewarm water and were left to sediment for approximately 12 hours. The faeces were discarded and the supernatant was sucked off, leaving the sediment in the bottom. The beaker was filled with water again, it was left to sediment for 15 minutes and the sediment was placed on a microscope slide for examination. The degree of infection was estimated as low, medium and high. *Muellerius capillaris*: low (less than 10 larvae per g faeces), medium (10-1,000) and high (1,000 and more). *Dictyocaulus filaria*: low (less than 5 larvae per g faeces), medium (5-50) and high (50-500).

The fluke egg sedimentation method was

used to isolate fluke eggs from faeces. Five grams of faeces were mixed thoroughly with 10-15 ml of tap water. The suspension was washed through two layers of gauze into a conical sedimentation beaker. The suspension was allowed to sediment for 10 minutes. The faeces were discarded, the supernatant was sucked off, and the beaker was filled with water and stirred. This procedure was repeated 2-3 times, until faecal debris had sufficiently decreased. Approximately 5 ml of sediment was then mixed with two drops of 1% malachite green solution, and left to sediment in a conical test tube for 10 minutes. The sediment was then placed on a slide for microscopic examination. The results were described as infected or not infected.

Results

Abomasum (Table 2)

In the abomasum, *Teladorsagia circumcincta*, *T. trifurcata* and *T. davtiani* were present in all 15 lambs. The average number was 2,839 per lamb (range: 300- 8,250), fairly evenly distributed between the four locations.

Trichostrongylus axei was also identified in the abomasum. However, this species was only found in lambs from two of the four locations – only a few were found in lambs from one location, and an average of 7,392 (1,818-12,627) per lamb was found in another location. Larvae were found in the mucosal membrane in all lambs. No attempt was made to make any identification of the larvae.

The mean proportion between larvae and adult *Teladorsagia* spp. was 1:7.4.

Small intestine (Table 3)

Nematodirus battus and *N. filicollis* were found in the small intestine of lambs from all four locations. *N. battus* was present in 14 of the 15 lambs (range: 100-16,580) and *N. filicollis* was present in 14 of 15 lambs (range: 193-9,153). From two of the locations, the majority was *N. battus* (95% and 74%); in one location, 82% were *N. filicollis*, and in the fourth location, the numbers were low, and there were almost similar numbers of *N. battus* and *N. filicollis*.

Location	Numbers of lambs	Larvae	*Teladorsagia*	*Trichostrongylus axei*
Saksun	4	99	2,214	0
Havnardalur	4	474	3,661	0
Streymnes	4	357	4,087	7,392
Kollafjørður	3	708	1,290	18
Total mean		410	2,813	

Table 2. *The mean numbers of nematodes in abomasum.*
Talva 2. Miðaltal av rundormum í vinstur.

Location	Numbers of lambs	*Nematodirus battus*	*Nematodirus filicollis*	*Trichostrongylus vitrinus*
Saksun	4	8,613	445	875
Havnardalur	4	1,093	4,994	7,425
Streymnes	4	2,979	1,033	14,900
Kollafjørður	3	381	511	2,700
Total mean		3,267	1,746	6,475

Table 3. *The mean numbers of nematodes in the small intestine.*
Talva 3. Miðaltal av rundormum í vilum.

Location	Numbers of lambs	*Trichuris ovis*	*Chabertia ovina*	*Oesophagostomum*
Saksun	4	1	5	3
Havnardalur	4	2	17	0
Streymnes	4	2	18	4
Kollafjørður	3	0	9	1
Total mean		1	12	2

Table 4. *The mean number of nematodes in the large intestine.*
Talva 4. Miðaltal av rundormum í skarngørnum.

Trichostrongylus vitrinus was present in every lamb examined. *Moniezia expansa* was found in the small intestine of one lamb.

Large intestine (Table 4)
Nematodes of the species *Trichuris ovis, Chabertia ovina*, and *Oesophagostomum venulosum* were found in small numbers.

Lungs
Muellerius capillaris larvae were found in the lungs of every lamb examined. *Dictyocaulus filaria* was found in two lambs.

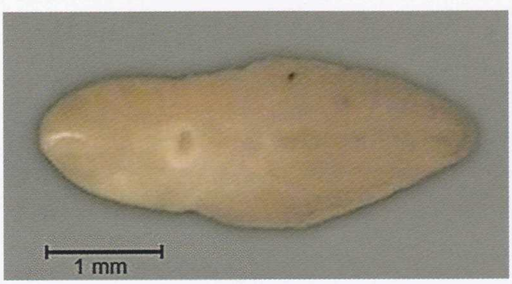

Fig. 2. *Fasciola hepatica, larva.*
Mynd 2. Fasciola hepatica, larva.

Fig. 3. *Cysticercus tenuicollis on liver surface.*
Mynd 3. Cysticercus tenuicollis (vatnbløðra) á livrarbroddi.

Liver
Young, immature stages (2-10 mm) of *Fasciola hepatica* were found in the liver of one lamb (Fig. 2).

Abdominal cavity
Cysticercus tenuicollis was found in the abdominal cavity of two lambs (Fig. 3).

Ectoparasites
Bovicola ovis and *Melophagus ovinus* were observed.

Faecal samples in connection with post mortem examinations (Table 5)
The faecal examinations yielded the following results: *Strongyle* type eggs: 960 (100-3,900). *Nematodirus* spp. eggs: 180 (0-600). *Eimeria* spp. oocysts: 2,916 (100-12,800). Figures indicate the mean of eggs

Location	Numbers of lambs	*Nematodirus*	*Strongyles*	*Eimeria*	*Trichuris*
Saksun	4	250	425	4.900	0
Havnardalur	4	50	700	3.775	0
Streymnes	4	375	2.375	2.075	0
Kollafjørður	3	33	267	1.167	0
Total mean		177	942	2.979	0

Table 5. *Mean numbers of eggs per gram (epg) in faecal samples. Post mortem material.*
Talva 5. Miðaltal av eggum fyri hvørt gram (epg) í tøðum. Tilfar frá heystinum 1998.

per gram (epg) in faeces. No *Trichuris* eggs were found, although some *Trichuris ovis* were found in the large intestine of the examined sheep. No attempt was made to make a more exact identification of the eggs.

Faecal samples: autumn, winter, and spring 1999 (Table 6)

The results are grouped into *Nematodirus battus* eggs, other *Nematodirus* eggs, strongyle type eggs, *Trichuris ovis* eggs, *Eimeria* spp. oocysts, *Dictyocaulus filaria* larvae, *Muellerius capillaris* larvae, and *Fasciola hepatica* eggs. No attempt was made to make a more exact identification of the parasites.

Results are graphically set up in Figs. 4-7. The figures show the distribution of parasites as epg or opg, and the distribution of larvae as proportion infected of examined lambs and ewes, respectively, for *strongyles, Nematodirus battus*, and other *Nematodirus* spp. in Fig. 4, *Trichuris ovis* in Fig. 5, *Dictyocaulus filaria* and *Muellerius capillaris* in Fig. 6, and *Eimeria* spp. in Fig. 7.

	1999	*Nematodirus battus*	*Other Nematodirus*	*Strongyles*	*Trichuris ovis*	*Eimeria spp.*	*Dictyocaulus filaria*	*Muellerius capillaris*	*Fasciola hepatica*
	Autumn	102	51	651	9	5.159	57%	60%	?
	Winter	0	13	96	8	383	63%	54%	8%
Lambs	Spring	70	29	1,066	30	736	76%	82%	0%
	Autumn	4	0	219	0	196	21%	79%	?
	Winter	0	3	83	11	240	19%	58%	12%
Ewes	Spring	4	29	539	18	109	46%	89%	4%

Table 6. *Numbers indicate mean egg – or oocyst numbers pr. gram of faeces. The proportion of sheep infected with Dictyocaulus filaria , Muellerius capillaris and Fasciola hepatica is also stated. Numbers of sheep examined are set up in Table 1.*
Talva 6. Tølini vísa miðaltal av eggum ella oocystum í hvørjum grammi av tøðum. Lutfallið av seyði, fongdur við *Dictyocaulus filaria, Muellerius capillaris* og *Fasciola hepatica,* er eisini sett upp. Talið av kannaðum seyði er sett upp í talvu 1.

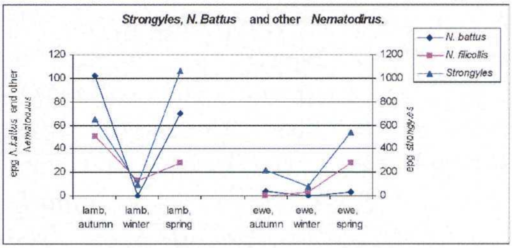

Fig. 4. Seasonal variation in epg for Strongyle type eggs, Nematodirus battus and other Nematodirus spp.
Mynd 4. Broytingar í epg gjøgnum árið. Nematodirus battus, aðrir Nematodirus og Strongylidur.

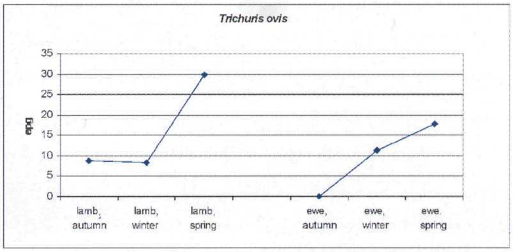

Fig. 5. Seasonal variation in epg for Trichuris ovis.
Mynd 5. Broytingar í epg gjøgnum árið. Trichuris ovis.

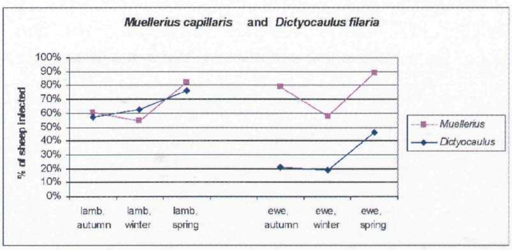

Fig. 6. Seasonal variation in proportion of sheep infected by Muellerius capillaris and Dictyocaulus filaria.
Mynd 6. Broytingar í lutfalli av seyði fongdur við Muellerius capillaris og Dictyocaulus filaria eftir árstíð.

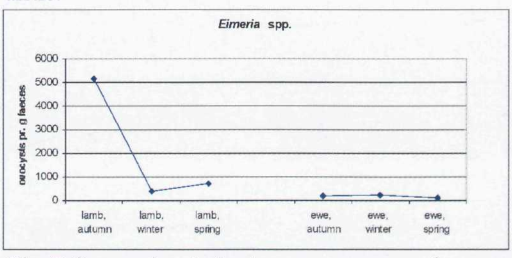

Fig. 7. Seasonal variation in oocysts pr. gram faeces for Eimeria spp.
Mynd 7. Broytingar í opg gjøgnum árið. Eimeria spp.

Identification

Identification was made by microscopic examination, using identification and classification methods described in, *e.g.*, Gibbons and Khalil, 1982; Lichtenfels and Pilitt, 1983; Hoberg *et al.*, 1985; 1986; Urquhart *et al.*, 1987; Lichtenfels and Hoberg, 1993; Hansen and Perry, 1994; Kassai, 1999.

Teladorsagia spp.

The adults are reddish-brown slender worms, occurring on the surface of the abomasal mucosa. The length is 0.6-1 cm. Females are longer than males. The larval stages occur in the gastric glands. The females of this genus are characterised by having annular rings at the tip of the tail, and have a small or no vulval flap. Both sexes have small papillae on each side of the cervix. *Teladorsagia* is characterised by a copulatory bursa in which the five lateral rays are arranged 2—2—1. The eggs are of the strongyle type. The *Teladorsagia* spp. are *T. circumcincta, T. trifurcata,* and *T. davtiani*. However, the two last types might be morphological variations of *T. circumcincta* (Lancaster and Hong, 1981; Stevenson *et al.*, 1996). The eggs are of the strongyle type.

T. circumcincta: The male is identified by the spicules. They are slender and relatively long, and are divided in the distal fourth. The dorsal and ventral branches are more than half as long as the main branch. (Fig. 8).

T. trifurcata and *T. davtiani:* These are difficult to separate morphologically. Spicules are relatively stout and divided at the beginning of the distal third. Their dorsal

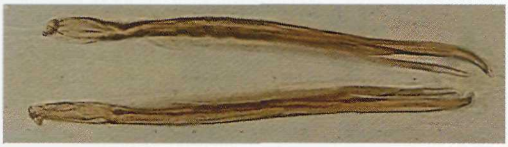

Fig. 8. Teladorsagia circumcincta. Spicules.

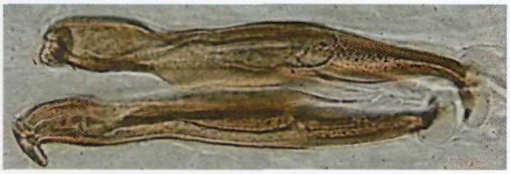

Fig. 9. Teladorsagia trifurcata-davtiani. Spicules.

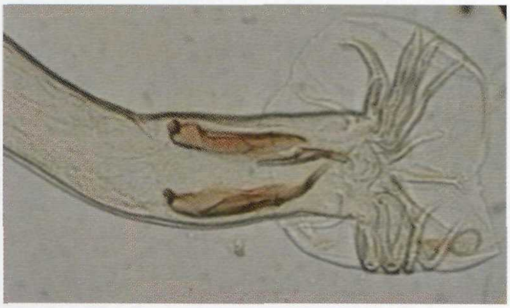

Fig. 10. Trichostrongylus axei. Spicules and bursa.

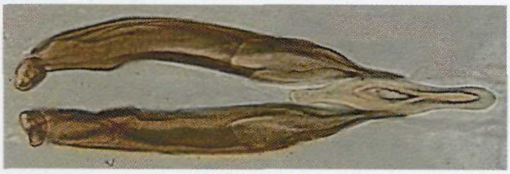

Fig. 11. Trichostrongylus vitrinus. Spicules.

Fig. 12. Nematodirus battus. Bursa

and ventral medial branches are about half as long as the main branch (Fig. 9). *T. trifurcata* has a sjoberg organ and *T. davtiani* has two distinct dorsal papillae on the genital cone.

Trichostrongylus spp.

These nematodes are found in the abomasum and in the small intestine. They are relatively small and hair-like, 2-8 mm in length. A characteristic feature is the distinct excretory notch in the oesophageal region. In the female, the tail is bluntly tapered, and there is no vulval flap. The eggs are of the strongyle type. *T. axei* is only found in the abomasum and the male is distinguished from other *Trichostrongylus* species by the unequal length of spicules. (Fig. 10).

T. vitrinus is found in the small intestine, and the spicules are equal in length. (Fig. 11).

Nematodirus spp.

These nematodes are found in the small intestine. The length is about 2 cm. When isolated from the intestine, the thin, twisted worms intertwine, creating a cotton wool-like appearance. A distinct cephalic vesicle

Fig. 13. Nematodirus battus. Egg.

is present. The anterior half of the worm is distinctly thinner than the posterior. The spicules are long and slender with fused tips. The eggs are relatively large (150-230 µm).

Nematodirus battus. The male is distinct from other *Nematodirus* spp. by the divergent lateral rays of the copulatory bursa. (Fig. 12). The tip of the spicules is bluntly pointed and heart-shaped. The female has a long, pointed tail. The eggs are brown, the morula fills out the eggshell, and the sides of the egg are parallel. (Fig. 13).

***Fig. 14.** Nematodirus filicollis. Bursa.*

N. filicollis. The male has two sets of parallel rays in each copulatory lobe, *i.e.* the lateral rays are parallel. (Fig. 14). The spicules are fused anterior to the tip. The female has a truncate tail, with a small spine. Eggs are ovoid and colourless. The morula does not fill out the entire eggshell. (Fig. 15).

***Fig. 15.** Nematodirus spp., egg.*

<u>*Trichuris ovis*</u>

This nematode is found in the large intestine. It is large (male 5-8 cm, female 3.5-7 cm), whip-like, with a long, thin anterior part (0.1 mm), and a thick posterior end, (1 mm). The male tail is coiled with a single spicule. (Fig. 16). The eggs are characteristically lemon-shaped with a plug in each end. (Fig. 17).

<u>*Chabertia ovina*</u>

This nematode is also found in the large intestine. The length is 15-20 mm. The worms are markedly truncated at the anterior end, due to a buccal capsule. There is a double row of papillae around the rim of the buccal capsule, but no teeth are present.

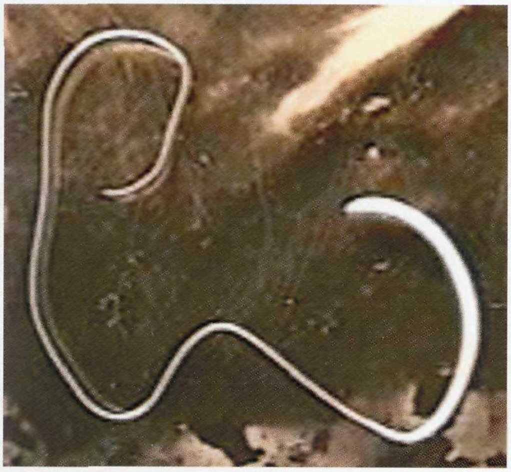

Fig. 16. Trichuris ovis.

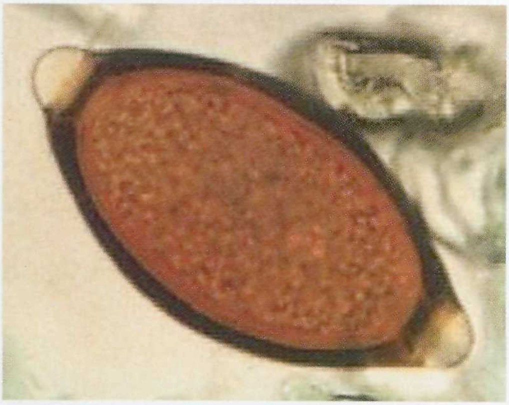

Fig. 17. Trichuris ovis. Egg.

(Fig. 18). The eggs are of the strongyle type.

Oesophagostomum venulosum

This nematode is found in the large intestine. The males are 11-16 mm in length, the females 13-24 mm, and both are 1 mm thick. They have a small buccal cavity surrounded by a leaf crown and cephalic and

***Fig. 18.** Chabertia ovina, buccal capsule.*
Mynd 18. *Chabertia ovina*, fremri endi.

cervical vesicles and cervical papillae. (Fig. 19). Papillae are situated posterior to the oesophagus in *O. venulosum.* Eggs are of the strongyle type.

Moniezia expansa

Found in the small intestine, it is up to 6 metres in length and 15 mm wide. Proglottides are much wider than they are long. (Fig. 20). The scolex is armed only with suckers. Eggs are 50-60 µm and triangular. (Fig. 21).

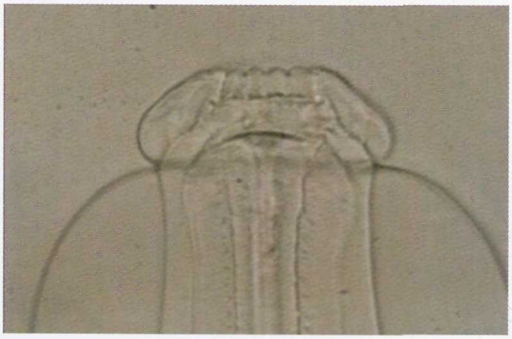

***Fig. 19.** Oesophagostomum venulosum, anterior end.*
Mynd 19. *Oesophagostomum venulosum*, fremri endi.

Fig. 20. Moniezia expansa.
Mynd 20. *Moniezia expansa.* Bendilormur.

Fig. 21. Moniezia expansa, egg.

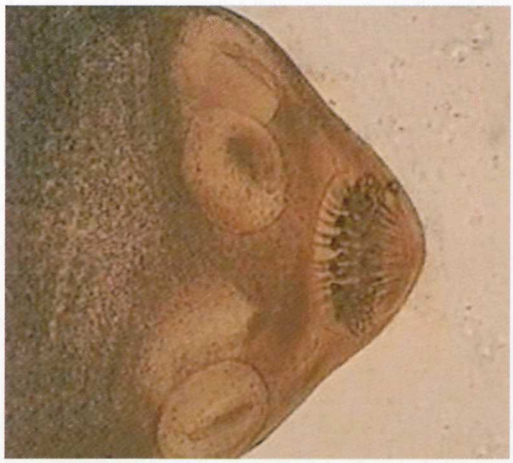

Fig. 22. Cysticercus tenuicollis, scolex with suckers and hooks.
Mynd 22. *Cysticercus tenuicollis,* høvd við súgviskálum og krókum.

Cysticercus tenuicollis
(Taenia hydatigena)
The tapeworm is found in the intestine of dogs. The cysticerci, which are up to 8 cm, are attached to the peritoneum of sheep. The scolex is armed with 4 suckers and hooks. (Fig. 22).

Dictyocaulus filaria
White worms, 3.5-9 cm in length, are found in the bronchi and trachea. (Fig. 23). Larvae ($L_{1,}$ first-stage larva) isolated from fresh faeces have a cuticular knob on the anterior end, dark intestinal granulation, and the tail is blunt and straight. (Fig. 24).

Muellerius capillaris
These are brown, hair-like worms, 1-3 cm long. The tail of the larvae (L_1) is characterised by specific cuticular structures at the posterior end. (Fig. 25).

Fasciola hepatica
The common liver fluke is 2-3 cm long, leaf shaped, and grey-brown, with a conical anterior end and caudally converging edges. (Fig. 26). It is found in the bile ducts and gallbladder. The egg is oval, golden yellow and 130-145 μm long.

Fig. 23. Dictyocaulus filaria in lung.
Mynd 23. *Dictyocaulus filaria* í lunga.

Fig. 24. Dictyocaulus filaria, larva.

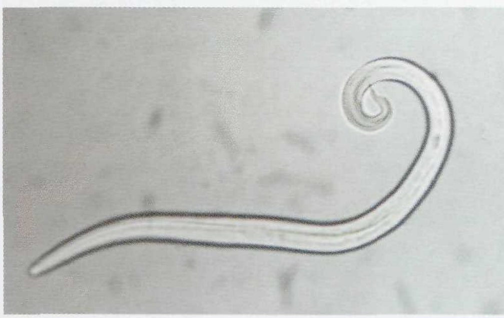

Fig. 25. Muellerius capillaris, larva.

Discussion

Post mortem studies

Nematodes in the abomasum

Teladorsagia spp. were found in all lambs included in this study. This is no surprise, as several studies conducted in climatic areas similar to the Faroe Islands, have showed the presence of *Teladorsagia* spp. (Rose, 1990; Gulland, 1992; Dyrmundsson *et al.*, 1996). The mean proportion of larvae to adult *Teladorsagia* spp. found in abomasal mucosa was 1:7.4. It is not examined in this study, but it might be expected, due to larval inhibition, that similar surveys in the winter would reveal higher proportions of larvae than the present study shows. *Trichostrongylus axei* was not a consistent finding, although it was found in considerable numbers in one location. The reason might be that horses had been grazing alongside sheep in this area. It has not been possible, however, to confirm that horses were not present in the other locations.

Haemonchus contortus was not found in this study. Considering the sensitivity of the free-living stages of *H. contortus* to low temperatures, and especially to repeated freezing and thawing conditions (Jasmer *et*

Fig. 26. Fasciola hepatica.
Mynd 26. *Fasciola hepatica* (livuriglar).

al., 1987), it was expected that *H. contortus* would not be present in the Faroe Islands. This is also consistent with a lack of findings in similar climatic areas: Iceland (Richter, 1974), Greenland (Rose, 1990), and on the island of St. Kilda in the Outer Hebrides (Gulland and Fox, 1992).

Nematodes and cestodes in the small intestine

Trichostrongylus vitrinus was found in every lamb in this study. Although there were significant differences in the numbers from one location to another, the results indicate that these parasites are widespread in the Faroe Islands.

Nematodirus spp. were numerous in most lambs examined in the autumn of 1998. The species identified were *N. battus* and *N. filicollis*. *N. battus* is a relatively "new" parasite. Records indicate that it originally was restricted to the British Isles, as it was first described there in 1951 (Crofton and Thomas, 1951). Then, it seemed to spread to several countries in Europe: Norway in 1961 (Helle, 1969), the Netherlands (Borgsteede *et al.*, 1978), Denmark (Thamsborg *et al.*, 1996), and in 1984 to the U.S.A. (Hoberg *et al.*, 1986). It is not known when *N. battus* was introduced to the Faroe Islands, but sheep imported from Scotland to the Faroe Islands in 1961 are a likely source of contamination.

Moniezia expansa is considered cosmopolitan. In this study, it is verified that the tapeworm is present in the Faroe Islands. Other observations made by the author indicate that it is common. *Moniezia* spp. is generally regarded as of little pathogenic significance.

Fig. 27. Muellerius capillaris. Lesions in lung.
Mynd 27. Muellerius capillaris. Broytingar í lunga.

Nematodes in the large intestine

Trichuris ovis, Chabertia ovina, and *Oesophagostomum venulosum* were found in small numbers in the examined lambs. These parasites are usually not considered as pathogenic to sheep, unless they are present in considerable numbers.

Nematodes in the lungs

Muellerius capillaris is a very common ne-

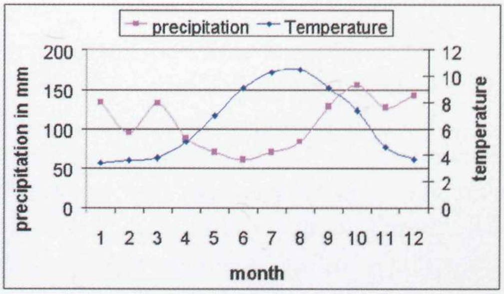

Fig. 28. Mean temperatures and precipitation pr month. 1961 to 1990 (Cappelen and Laursen, 1998).
Mynd 28. Miðalhiti og -avfall um mánaðin frá 1961 til 1990 (Cappelen and Laursen, 1998).

matode found all over the world. The prevalence was very high in this study, and the macroscopic changes in sheep lungs normally associated with this nematode infection are very well known in the Faroe Islands. (Fig. 27). Pneumonic signs are rarely observed in combination with *Muellerius* infection, thus, the pathogenic effect on sheep is considered low.

Dictyocaulus filaria is also a nematode that, according to this study, seems to be widespread. This lung parasite is considered to be more pathogenic than *Muellerius capillaris*. Clinical symptoms as coughing in conjunction with *D. filaria* infections are commonly seen.

Flukes in the liver

The common liver fluke is found in temperate areas and in high altitudes in the tropics and subtropics. In the Faroe Islands, *Fasciola hepatica* has been described as a very common sheep parasite (Lützen and Bovien, 1934). In the present study, flukes were only found in one lamb, and these were early immature stages, 1-4 mm in length. Bearing in mind the life cycle of *F. hepatica* and the systematic use of flukicides, it was not expected that the incidence would be high in lambs. The development of the *F. hepatica* larvae, both in the environment and in the intermediate host, is dependent on temperature and humidity. Minimum temperature required for miracidia to infect the intermediate host is 5-6°C, and the optimum is in the range between 15 and 26°C (Christensen and Nansen, 1976). For development of both *F. hepatica* larvae and its intermediate host, *Lymnaea truncatula*, a mean day/night temperature of at least 10°C is needed (Kassai, 1999). In the Faroe Islands, the highest mean temperatures at sea level are reached in July and August, 10.3 and 10.5°C, respectively, (Fig. 28), and in altitudes higher than 100 metres the temperatures never reach a mean temperature above 10.0°C. Consistent with this, *L. truncatula* has not been found at altitudes higher than 100 metres in the Faroe Islands (Jensen *et al.*, 1928-1971). It is expected that with these climatic conditions the development from egg to infective metacercaria will be only just possible in the Faroe Islands, and that development may take a relatively long time.

Faecal examinations – epidemiological studies

Strongyle type eggs

No attempt was made to differentiate between these eggs, as they may be from any of the following nematodes, identified in this study: *Teladorsagia* spp., *Trichostrongylus* spp., *Trichuris ovis*, and *Chabertia ovina*. If one compares the egg numbers with the post mortem examinations described above, it is likely that the majority of these eggs belonged to *Teladorsagia* spp. and *Trichostrongylus* spp. The egg counts were generally higher in lambs than in ewes. The autumn mean epg count in lambs was 651 and in ewes 219. It fell to around 90 epg in both lambs and ewes in winter and then rose to 1,066 in lambs and 539 in ewes in the spring (Fig. 4). The fall in epg in the winter is likely to be due to increased resistance and the anthelmintic treatment the previous autumn. The rise in the spring is expected to be due to a phenomenon described in several studies from other countries, the periparturient egg rise. This is seen in ewes in the period two weeks before lambing until six weeks after lambing. The faecal egg discharge is intense in this period and it builds up a massive population of infective larvae on the pasture, to be ingested by the susceptible lamb generation.

Nematodirus spp

Nematodirus battus: There was a significant difference between epg in lambs and ewes with a mean epg in ewes never higher than 4, and with a mean of 102 epg in lambs that were about five months old. This indicates development of a considerable degree of resistance in sheep older then one year. Faecal egg count in winter drops to zero for all lambs and ewes, most likely due to acquired resistance and anthelmintic therapy in the autumn and winter, and rises to a mean count of 70 epg for lambs in the spring (Fig. 4).

The typical pattern of transmission is considered to be that only one parasitic generation of *N. battus* occurs per season. Eggs develop to infective third-stage larvae, but do not hatch until the larvae have been exposed to freezing (Gibson and Everett, 1981) followed by periods with moist conditions and mean night/day temperatures above 10°C (Thomas and Stevens, 1960). These conditions lead to a synchronous hatching in the spring, followed by transmission to the lambs concentrated in a few weeks. Autumn transmission has been reported in England, Scotland, and Norway, but the spring transmission is considered typical (Rickard *et al.*, 1989).

In this study, lambs younger than five months have not been examined. It is, therefore, not possible to comment on transmission to younger lambs, but the results indicate that there is a spring transmission. In addition, both faecal egg counts and post mortem examinations indicate that autumn transmission is common. Studies in Oregon show that transmission seems to be year round with major peaks in the autumn and through the winter. It is suggested that these results might be correlated to high precipitation rather than to temperature (Rickard *et al.*, 1989). If these suggestions are reliable, precipitation might be a major factor in *N. battus* development and transmission in the Faroe Islands, as rain is abundant and precipitation totals are highest in autumn and winter, and mean night/day temperature only just exceeds 10°C (Fig. 28). The relative humidity is high, normally 88% annually in Tórshavn, and is highest around August (Cappelen and Laursen, 1998).

The egg counts for other *Nematodirus* spp. showed that the distribution was more even between seasons and between lambs and ewes than found for *N. battus*. It is likely that these *Nematodirus* spp. found in the faecal examinations were *Nematodirus filicollis*, as these were the only *Nematodirus* spp. found in the post mortem examinations described above.

Trichuris ovis

The egg counts are generally low with the highest peak in spring: 30 epg in lambs and 18 epg in ewes (Fig. 5). These figures are very low, and infection can not be considered to be of any hazard to the sheep.

Muellerius capillaris

In general, there seemed to be a slight tendency that a greater proportion of ewes than lambs was infected. In the autumn when the lambs were five months old, the results show that 79% of ewes and 60% of lambs were infected (Fig. 6). These results indicate that infected sheep do not develop any significant immunity. The number of larvae per gram of faeces was not counted, but an estimate was made that showed that there was a large variation, from zero to several thousand larvae per gram of faeces.

Dictyocaulus filaria

There was a significant difference between infected lambs and infected ewes in all seasons, with a greater proportion of lambs infected (Fig. 6). This gives a clear indication of the development of resistance in older sheep.

Fasciola hepatica

Fluke faecal egg count in the winter of 1999 showed that 8% of lambs and 12% of ewes were infected, and in the spring of 1999 that no lamb and 4% of the examined ewes were infected. The number of eggs identified were, in all positive samples, less than one epg. As all sheep were treated with flukicides in the previous autumn, it was expected that the infection rate would be low.

Eimeria spp.

Several species of *Eimeria* were found in this study, although no attempt was made to identify the species. The results showed that *Eimeria* spp. were found in significantly greater numbers in lambs five to ten months old than in ewes older than one year. Furthermore, the highest mean count was found in lambs five months old, exceeding 5,000 oocysts per gram of faeces (opg), then falling below 400 opg in lambs eight months old, and then rising to above 700 in the spring, when lambs were 10 months old (Fig. 7). As lambs were not treated against Eimeria, the drop in opg from four months to eight months is undoubtedly due to increased resistance, and the small rise in the spring is likely caused by soil contamination. In order to obtain a better overview of resistance development, it will be necessary to obtain samples at lower ages and at more frequent intervals.

General discussion

Although *Fasciola hepatica* was considered to be the main parasite hazard in sheep before medication was available, it now seems to be of little importance. In other countries, *Nematodirus battus* is demonstrated to be a serious pathogen of lambs in the first, mild period after winter. Even though the study found considerable numbers of *N. battus*, it is hard to conclude, however, the existence of spring nematodiriasis, because of a lack of observations in that period. *Haemonchus contortus* was not found. This is a positive finding, as it is considered to be a very important parasite in sheep.

In general, the results indicate that parasites in sheep are widespread in the Faroe Islands, and that their importance is not to be underestimated. Most farmers treat their sheep with anti-parasitic drugs two to three weeks before lambing to reduce the periparturient egg rise in mid-summer, and in the autumn as well to free the sheep from parasites before the winter.

Some farmers treat their animals in winter, but the present study suggests that this is not necessary, although there seems to be high numbers of both *Dictyocaulus filaria* and *Muellerius capillaris* larvae in faeces (Fig. 6). The solution might be that farmers could use anthelmintics if sheep are coughing or if faecal samples are positive.

In general, the recommendations are that faecal examinations should be used more frequently in connection with anti-parasitic treatment. Strategic management and anti-parasitic medication do play an important role in lowering the risk of both clinical and sub-clinical parasitism.

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